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ARTICLES

NOTES ON THE ECOLOGY OF *CULISETA* MOSQUITOES FOUND IN THE PACIFIC NORTHWEST

W. W. YATES

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The genus *Culiseta* Felt, tribe Culicini, is represented by five species in the Pacific Northwest—*morsitans* (Theo.), *inornata* (Will.), *impatiens* (Wlkr.), *incidens* (Thom.), and *maccrackenae* D. & K. Only *inornata* and *incidens* are abundant or widely distributed enough to be of economic importance. *C. morsitans* and *maccrackenae* are rare species found in small numbers in only a few localities. *C. impatiens* is more widely distributed, but its range is limited to wooded mountain areas.

The information presented here has been compiled from field notes and observations made by the writer and other personnel [1] connected with the Corvallis, Oreg., field station of the Bureau of Entomology and Plant Quarantine over a period of 21 years. The territory covered includes Oregon, Washington, and Idaho.

Culiseta maccrackenae: This species has been found in only a few localities in southwestern Oregon. The larvae were taken in August in fresh-water ditches and pools, the borders of which were lined with trees and brush. Associated with them were *Culiseta incidens, Culex territans* Wlkr., and *Culex stigmatosoma* Dyar.

Culiseta morsitans: This species has been found only in Oregon and Washington. Most of the larvae were collected in spring and early summer and were found only in dense tule swamps. Associated with *morsitans* were *incidens* and *Culex tarsalis* Coq. One August collection of larvae made near Ellensburg, Wash., was from the bogs of a nearly dry swamp filled with reeds and tules, and associated with them were larvae of *inornata* and *Anopheles* sp. *C. morsitans* larvae are difficult to find, as they seek shelter in the most inaccessible places where tules and other swamp vegetation are the heaviest.

Light traps have taken a few adults in several locations where larvae could not be located. Traps located at Ft. Stevens and Scappoose, Oreg., and at several places near Yakima, Wash., captured adults from June to September, and a trap near Sunnyside, Wash., from May to September.

Culiseta impatiens: This species is found in timbered mountain areas. It has been collected in all three states. The usual larval habitat is shady pools bordering mountain meadows, but occasionally larvae are found in open, unshaded pools. They appear soon after the snow melts in the spring, but collections have been made as late as August. These summer collections have all come from shady, cool situations. The author's earliest collection was made in April. Several species of *Aedes* are found associated with *impatiens* and occasionally *incidens* or *inornata.* Not much information has been obtained on the adults. They are timid but severe biters. A few have been taken in hand collections of mosquitoes and occasionally in light traps.

Culiseta incidens: This is a common mosquito in western Oregon and Washington. It is also found throughout the rest of the Northwest, but is rather rare in southeastern Oregon and southern Idaho. It breeds from sea level to elevations around 5000 feet. Larvae have been taken from brackish water in rocks along

[1] Including H. H. Stage, C. M. Gjullin, E. F. Knipling, and A. W. Lindquist.

the coast and in pools on the margin of tidal flats. They are found in stagnant ponds, woodland pools, and are numerous in log ponds, all of which contain acid water heavily charged with organic material. The larvae, however, have not been taken in alkaline water or in water grossly contaminated with sewage or animal excretions. They are also found in ornamental lily ponds, along the borders of sluggish streams, in roadside ditches, and in many types of artificial containers, such as rain barrels and empty cans, and occasionally in tree cavities and cellars. Stock-watering troughs are favorite breeding places, especially in early spring. Hydrogen-ion determination of waters from 11 geographical locations gave an average pH of 6.7 with a range of 6.1 to 7.4. Maximum reproduction of *incidens* occurs in cool to moderate temperatures. This species is more numerous in early spring and late fall. Early-spring breeding is usually in open, sunny situations, and during the midsummer months it is confined to cooler, shady places.

A rain barrel standing in an open, sunny place was kept under observation one entire season. Egg rafts of *incidens* were first seen on March 29. Until about the last of May this was the only species present. At that time *Culex tarsalis* and *pipiens* L. appeared and gradually increased in numbers while *incidens* decreased until by midsummer it had disappeared. In September *incidens* appeared again in numbers and continued breeding until November.

In the hotter interior section of Oregon, midsummer larval collections have come from cool, shady places. For example, three collections made in Klamath County in August, 1932, all came from well-shaded locations and from cool spring water.

C. incidens is the first species to become active in the spring and the last to breed in the fall. Egg rafts and larvae were found one year in February and in most years by March they are rather common. The latest fall date larvae were observed was December 8. *C. incidens* is usually found alone in the early season. Later it is commonly associated with *Culex tarsalis* and *Anopheles punctipennis* (Say) and less commonly with *Culex pipiens, stigmatosoma, apicalis* Adams, and other species of *Culiseta.*

The females overwinter. They have been taken from root cellars in late winter in Yakima County, Wash., and from vacant cabins, sheds, and storage rooms throughout the winter in the Willamette Valley. The life cycle of *incidens* is longer than that of some other species. Under controlled laboratory conditions at 80° F. it required 17 to 18 days. In an outdoor shaded cage during July and August at temperatures slightly above normal it required 28 to 30 days.

C. incidens is not a serious pest of man; its preferred hosts are fowls or domestic animals. However, under certain conditions and in some localities it is very annoying to man. It will readily enter houses, and bites at dusk or in deep shade. The females are timid and easily repelled, but they bite severely. Records of 10-minute collections show that a small number of *incidens* have been taken biting, and it is also interesting to note that these collections were made on cool, cloudy days.

Culiseta inornata: This species is well distributed throughout the Northwest, but is especially abundant in the interior irrigated areas. The larvae have been found near sea level and at elevations over 6000 feet. *C. inornata* breeds under various conditions. These diversified habits suggest that there may be two or more strains of the species. It is found in western Oregon and Washington in cool, shady places, at high elevations in cold water, and in greatest numbers in midsummer in open, waste irrigation water. Although the species is well distributed throughout the more temperate areas, it is never found in great numbers. Perhaps high temperature and sunlight are optimum conditions for maximum reproduction. The larvae prefer alkaline or neutral water. They have been found in numbers in pools where the

ground was white with alkali deposits. Hydrogen-ion determinations of breeding waters showed them all to be alkaline except water from a woodland pool, which had a pH of 6.4.

Only scattered and limited breeding of *inornata* was found on field trips through eastern Oregon and southern Idaho in April and early May, but when the same areas were revisited in June and July the species was abundant. In western Oregon and Washington few larvae have been collected before the middle of May. The author's information on how late the species will breed in the fall is limited, but late-September collections have contained all instars of larvae as well as pupae.

In areas west of the Cascade Mountains *inornata* is usually found associated with *incidens, Culex tarsalis,* and *Anopheles punctipennis;* in mountain areas with *Culiseta impatiens* and sometimes with *Aedes* sp.; and in irrigated areas with *Culex tarsalis* and *Anopheles freeborni* Aitken. In the last habitat it was produced in large numbers in poorly drained areas, where surplus water collected in depressions and roadside ditches. Overwintering females have been collected from root cellars in Yakima County, Wash., and from sheds and outbuildings in other localities.

C. inornata is numerous enough in many localities to be a serious pest to domestic animals, which appear to be its preferred hosts. It will bite man, although timid and easily discouraged. Ten-minute collections of mosquitoes taken in areas where *inornata* is common usually contain a small percentage of this species. It will mate and reproduce under laboratory conditions. In one case newly emerged males and females confined under a lantern globe over water were observed mating the same day they emerged.

Collections from a light trap operated for a number of years in each of several locations give some interesting information on the geographical and seasonal distribution of the species. These collections show that *inornata* is much more numerous in irrigated sections in eastern Oregon than in western Oregon. Not only were the daily catches larger but also a higher percentage of the total mosquitoes caught was *inornata.* The records for the Willa-

TABLE 1.—Trap collections showing seasonal abundance of mosquitoes and prevalence of *Culiseta inornata*

Location	Years	Average daily catch of mosquitoes					Per cent of *inornata* in total catch				
		May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
Willamette Valley, western Oregon:											
Vicinity of Portland	4–8	—	1.1	1.0	0.5	0.4	—	4.9	4.1	2.8	2.9
Scappoose	1–2	2.2	2.1	2.5	3.5	4.8	30	3	1.3	3	5.5
Fern Ridge Dam	1–4	—	1	2.3	1.3	0	—	13.3	15.9	12.7	0
Cottage Grove Dam	3	—	.4	.4	.2	—	—	39	26	18	—
Average	—	2.2	1.2	1.6	1.4	1.7	30	15	11.8	9.1	2.8
Irrigated areas:											
Summer Lake, eastern Oregon	2–3	—	99	181	142	—	—	37.5	28.5	39	—
Three locations in Idaho in 1944	—	0	.5	1.3	1.9	—	0	6.5	6.7	18	—
Ellensburg, Wash.	1–2	1.2	6.3	6.9	12.3	14.1	80	72	29	27.4	26.3
Sunnyside, Wash.	1–2	1.1	.9	.5	1.0	2.1	3.2	8	1.4	1.6	8.8
Buena, Wash.	2	.6	1.4	2.9	9.2	6	17	21.8	—	—	—
Yakima, Wash.	2	.3	1.4	2.6	2.9	3.0	30	11.5	7	8	16
Naches, Wash.	2	1.1	2.4	2.9	4	—	42	18	11	14	—
Average	—	.7	16	28.3	24.8	6.3	28.7	25	13.9	18	17

mette Valley show a rather uniform distribution throughout the summer. The collections from irrigated sections show an average increase in numbers from May to July and then a decrease in September.

Summary: Five species of *Culiseta* mosquitoes are known in the Pacific Northwest, but only two, *incidens* and *inornata,* are of economic importance. *C. morsitans* and *maccrackenae* are rare species with limited distribution. *C. impatiens* is found in limited numbers only in wooded mountainous regions.

C. incidens finds optimum environment in the temperate climate of Oregon and Washington, but occurs in limited numbers throughout the region. The larvae prefer cool, acid water, and are the first species to be found in early spring and the last in the fall.

C. inornata is well distributed throughout the Northwest, but is of economic importance only in irrigated sections, where it breeds in large numbers in waste irrigation water. This species prefers alkaline water, and maximum reproduction occurs during the midsummer months.

Both species overwinter as adults. They occasionally bite man, but are more important as pests of livestock or poultry.

THE BLACKFLY PROBLEM IN ALASKA

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Extensive studies of biting Diptera in Alaska have been undertaken during recent years. Although the work was carried on most intensively during the summers of 1947 and 1948, studies were continued by various workers associated with the Alaska Insect Control Project through 1951. This project was conducted by the U. S. Bureau of Entomology and Plant Quarantine under a transfer of funds from the Department of Defense to the Bureau. Much of the work was directed toward solution of the serious mosquito problems of the Territory, but as time and resources permitted studies were made of the biology and importance of the other biting Diptera. The importance of blackflies as pests of man and livestock in many parts of the United States and Canada made it imperative that as much as possible be learned about these insects in Alaska.

The studies on biology and taxonomy confirm earlier reports of the abundance of blackflies in Alaska, and show that at least 36 species are found there (Stone 1952). This is a larger number than is now known from any State in the United States or from any Province of Canada. Many of the species that cause severe pest problems in the United States and Canada are abundant in Alaska, yet curiously enough there have been few records of blackflies actually biting man. Reports are numerous of annoyance caused by swarms hovering about people's heads and crawling about their faces. Local residents relate stories of hunters and miners who have suffered severely from the bites of "gnats," which were probably blackflies, but in some cases might also have been one of the very large species of *Culicoides* common in Alaska.

During 1948 three survey trips were undertaken, which covered most of the highway system of Alaska. Observations were made at approximately 200 localities, most of which were visited twice and many three times during the season. Observations were also made at Naknek in

southwestern Alaska. Specimens were collected at all localities and subsequently identified by Alan Stone.

The largest population was seen at Naknek during the first week of June. This was predominantly *Similium vittatum* Zetterstedt and was a source of severe annoyance to personnel of the air base. Another large population, consisting mostly of *venustum* Say and *tuberosum* (Lundstroem), was observed continuously along the Steese Highway from 20 to 60 miles northeast of Fairbanks on June 25.

During the July survey trip blackflies were encountered at 64 of the 173 stations where mosquito counts were made. The highest landing count was 100 (on the front and back of two men during 68 seconds) at mile 1377.5 on the Alaska Highway about 48 miles west of Tanacross.

The last survey trip was made between August 22 and September 8. This time blackflies were encountered at 54 out of 141 localities, and at 27 of them were present in sufficient numbers to give landing counts in excess of 4. The only annoying populations were encountered near Nabesna on August 28 and at Mentasta on August 29. Collections of the populations sampled during July and August were predominantly *venustum* but included *tuberosum* and *decorum* Walker as well as considerable numbers of *aureum* Fries and *vittatum*.

No actual biting was recorded either at Naknek or at any of the other localities mentioned. During the August-September survey the four men in the party received a total of only five bites. These bites were not observed, but were identified later by their characteristic appearance.

During this survey several people were interviewed who had recently been bitten by blackflies. One man at Eureka Lodge had a serious hand infection, which appeared to have been caused by a blackfly bite. Another at Sourdough Lodge had been badly bitten on the forearms while dressing a moose. He commented that the "gnats" seemed to bother only the parts of his arms that had been smeared with blood. At Northway two carpenters told of having been annoyed by blackflies two days before our visit. They were working side by side, and one man was severely bitten on the forearms and lower legs. The other man was not bitten, though the blackflies had caused him considerable annoyance by crawling into his eyes and nostrils.

Three other cases of blackfly annoyance came to our attention during the survey activities. A road crew of the Alaska Highway Commission were annoyed and received some bites on July 9 at Sheep Creek, about 19 miles north of Valdez. An Army engineer unit working 37 miles north of Valdez suffered considerable annoyance from crawling and biting blackflies on August 26. On September 8 the proprietor of the Chicaloon Lodge told of sheep hunters who had been recently bitten by a "yellow fly" in Carbon Creek Canyon. The eyes of the men were swollen almost shut. *Prosimulium fulvum* (Coquillett) seemed to be the only species fitting the description, and it was the one causing most of the annoyance at Sheep Creek on July 9.

Observations were continued in the Anchorage area by K. M. Sommerman and her assistant, L. H. Dover, until the end of October. During July and August limited flight sampling had yielded *venustum, tuberosum, vittatum,* and *arcticum* Malloch and/or *corbis* Twinn (females of *arcticum* and *corbis* can not be distinguished) from the lowlands. *Prosimulium hirtipes* (Fries) and *fulvum* were taken at higher elevations in the nearby mountains.

During September the picture changed, with *venustum* and *tuberosum* greatly reduced in numbers and replaced by *arcticum* and/or *corbis*. The latter were common in the lowlands and equally plentiful at elevations of 2,500 feet in the Chugach Range. *S. vittatum* and *decorum* were also taken in the lowlands. *P. hirtipes* and *fulvum* continued to be common in the mountains, and *hirtipes* was becoming an aggressive biter.

During October *arcticum* and/or *corbis*

was the common species in both lowlands and mountains and was an active biter. *P. hirtipes* also continued to be aggressive in both areas. *P. fulvum* was taken from both locations, but did not bite. *S. latipes* (Meigen), *decorum,* and *venustum* were also taken in flight samples from the lowlands.

In late September and early October the blackflies engaged in much crawling and probing before they actually commenced biting, but by the middle of October biting was direct, and in late October they bit as soon as they landed. The highest biting rate observed was one *arcticum* and/or *corbis* per minute per person on October 13, when the sky was overcast, the temperature 40° F., and the air movement barely perceptible. From late September through October flight activity was observed at temperatures of 37° and above (49° upper observation limit) at times when there was no air movement or only a slight breeze. Sky conditions did not seem to affect activity, as flight was observed in bright sunshine as well as on overcast days, during gentle rain and light snow precipitations.

The fall blackfly activity in the Anchorage vicinity is remarkable compared with that noted in other parts of Alaska. It is not known whether the conditions observed there are typical of other Alaskan regions during the same season. From our observations it appears that the behavior of blackflies belonging to the same species is different in the fall from that observed in the summer.

During the August-September survey no activity was observed at temperatures below 44° F., and there were only 10 positive counts among 46 observations taken between 44° and 49°. At these temperatures the average landing count was 6. By contrast there were 21 positive counts out of a possible 31 between 56° and 61°, and the average landing count was 9.6.

Similar observations late in June, 1951, at Kotzebue revealed no blackfly activity at temperatures lower than 51° F., though the flies were continuously present at temperatures higher than 53°. One sweep count (four sweeps with a 15-inch net on the windward and four on the leeside of an observer) of 54 was taken at 59°. Furthermore, the flies, which judging from a flight sample consisted entirely of *venustum,* bit the two observers mercilessly. Despite head nets and gloves they received a total of 35 bites during one 7-hour period of flight activity.

Observations at Nenana earlier in June as well as at Fort Yukon in mid-July yielded results similar to those obtained at Kotzebue, except that the populations were smaller and much less aggressive. Biting counts at Nenana were undertaken by one observer at mid-day on June 15. Sweep counts were consistently between 6 and 18, and it was necessary to wear a head net to avoid annoyance. In a period of 90 minutes, during which the observer exposed one forearm, an average of 3 blackflies per minute landed on the bared surface. Their usual procedure was to land and immediately fly off. However, after 60 minutes one landed and bit immediately; 10 minutes later a second bite was received. Both flies fed to repletion and left wounds that were troublesome for several days. One of the two was captured and identified as *decorum.* Based on a flight sample, most of the population consisted of *venustum.*

At Fort Yukon during mid-July of 1951 blackflies were causing local residents much more annoyance than were mosquitoes. The mosquito population, however, was exceptionally low. Several people were complaining of bites, but it was evident that some *Culicoides* annoyance was being attributed to the blackflies. The two observers were each bitten at least once. The highest sweep count was 38 recorded at 6 P.M. on July 14. This population was also composed largely of *venustum,* but as at Nenana the one fly captured in the act of biting proved to be *decorum.*

From these observations it is clear that blackflies in Alaska may at times be serious pests both as crawling nuisances and as biters. At present we have no certain explanation for the aggressive biting behavior of *venustum* at Kotzebue and the lack of biting records for this species in

other parts of Alaska. Neither have we an explanation for the behavior of *articum* and/or *corbis,* so far reported only as a crawling nuisance during the summer but biting readily in the Anchorage area in late fall at air temperatures well below the minimum temperature for flight activity recorded earlier in the season. *P. hirtipes* has also shown the same tendency, biting much more readily in late October than in September.

Many of the observations reported here are contradictory, and the importance to be assigned to Alaskan blackflies is still a matter of conjecture. It is quite possible that the differences in the behavior of a species at different times and places reflect racial adaptations to local conditions. The fact that *venustum* readily bites man at Kotzebue though not elsewhere in Alaska is suggestive. Since pre-Columbian times the human population of interior Alaska has consisted of scarcely more than a few hundred people scattered over a vast expanse of land in which wildlife, including several species of the larger mammals, has been relatively abundant. In such an area there would be little opportunity for blackflies to feed on man. By contrast Kotzebue has been the site of a sizeable village for at least 700 years.

If the question is one of host preference, then the importance of blackflies can be expected to increase rapidly as the population of Alaska grows. Such growth is already proceeding at a rapid pace and will doubtless be accelerated by the increasingly great strategic and economic importance of the Territory. With a larger population the wild host animals will in all probability become less numerous, and the blackflies may be expected to turn, from necessity, to feeding on man and his domestic animals.

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PREPARING MOSQUITO EGGS FOR EMBRYOLOGICAL STUDY

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There is, at present, a great deal of interest in the biology of mosquitoes. To understand their development, methods of preparing the eggs for embryological study are needed. DeCoursey and Webster (1952) have described a method for clearing the chorion of *Aedes sollicitans* (Walker) which permits a rough appraisal of the degree of development. McLintock (1951) had done some work on the egg shells of *Culiseta inornata* (Will) using a modification of the Crabb (1949) technique of double imbedding in celloidin and paraffin for sectioning. This method is satisfactory for the very early stages of the *Aedes hexodontus* Dyar eggs used in the present writer's work but does not give good results after the chorion has completely hardened. With Japanese beetle eggs Gesè (1952) used a cedar-wood oil process prior to imbedding which softens the chorion and permits sectioning. This, however, is not effective with *Aedes hexodontus* eggs. Most of the workers on *Drosophila* use dechorionated eggs which fix and imbed readily with standard techniques (Demerc, 1950). Mosquito eggs can be dechorionated but only after they are 48 hours old when the transparent embryonic cuticle, which is resistant to sodium hyperchlorite, has formed. Fixatives enter the dechorionated egg rather

readily and it is not difficult to section them. If the eggs are not dechorionated the problem begins with fixation. Since no known fixative will penetrate the eggs in less than two or three hours and most fixatives require days, the eggs must be punctured with a fine needle while in the fixative. Since puncturing must be done with the stages prior to the formation of the cuticle it is convenient to puncture all the material and this means that the chorion has to be dealt with in sectioning. With standard techniques paraffin enters through the puncture and infiltrates the yolk and developing embryo but there is little or no infiltration of the very dense chorion. When sectioned, the hard, brittle chorion breaks apart and falls out of the imbedding block damaging the section. Although a few sections per egg may be usable, the majority are worthless. To improve the infiltration of the chorion, clearing agents such as toluol, benzol, naphtha, chloroform and dioxane as well as xylol were used with no added success. Infiltration under a partial vacuum gave no better results. To hold the chorion in the imbedding block a mixture of beeswax and paraffin, half and half, was tried but it was difficult to work with and showed little improvement over paraffin.

A satisfactory method was finally discovered using Mayer's chlorine technique as described in Lee (Gatenby & Beams, Ed. 1950) which removed the pigment from, and softened the chorion. The eggs were taken from the 70 percent alcohol in which they were stored and placed directly in the bleach. In about one half hour the chorion became light brown and transparent, the results being similar to those shown in the photographs published recently by DeCoursey and Webster (3) using aqua-regia. No harm resulted to the tissue even if left in the bleach for an hour. The eggs were then washed in 70 percent alcohol, dehydrated in absolute alcohol or carbol-xylol and cleared in xylol. In xylol, morphological features could be studied through the light brown chorion. When the bleached eggs were infiltrated with paraffin for from 2 to 12 hours they gave good sections in nearly all of the cases. Since there was a tendency for the sections to wash from the slide during the staining procedure they were attached with celloidin. The tissue stained readily with Feulgen and hematoxylin stains.

Another satisfactory method of sectioning the eggs involved double imbedding in plastic and paraffin. The eggs were dehydrated in absolute alcohol and placed in a solution of n-butyl methacrylate and catalyst, using a gelatin capsule of convenient size as a mold. The plastic used was n-butyl methacrylate obtained from Rohm and Haas Co., Philadelphia. Ten cubic centimetres were mixed with 0.3 gms. or less of catalyst. The catalyst was Luperco CBD obtained from the Lucidol Division, Novadel-Agene Corp., Buffalo, New York. The mixture remained unpolymerised at 4° C. and polymerised to the solid at 50° C. The capsules were covered and placed at 50° C. and in eighty percent of the cases the plastic hardened in from 6 to 8 hours. Those capsules which did not harden were drained and refilled with new plastic. The hardened capsules were placed in water up to the lip until the gelatin softened and could be removed. The plastic remaining was trimmed, dehydrated in absolute alcohol for 2–3 minutes and placed in xylene for the same amount of time. It was then placed in melted paraffin for no more than 2 hours and imbedded in the standard manner. Sections were easily made at 10 microns. It was found convenient and almost necessary to run the sections onto the surface of water in a box attached to the microtome knife as is done in sectioning material for the electron microscope (Beams, *et al.*, 1952). If water was not used the static electricity generated by the plastic made the ribbons most difficult to handle. The ribbons readily spread on warm water and became firmly attached to a clean slide or a slide coated in egg albumen. Both the paraffin and the plastic

were easily removed in xylol in 15 to 20 minutes and if the slide was coated with celloidin the sections remained in place.

In the method where the chorion is bleached the chorion may sometimes separate from the surrounding paraffin and curl. In the plastic and paraffin technique the inner tissue sometimes becomes detached from the more firmly held chorion and may become distorted. Comparing both methods the saving in time and the ease of handling the material makes the bleaching technique the most practical for mosquito eggs. The double imbedding with plastic and paraffin may prove to be of value in other situations where a brittle object is to be sectioned serially.

Since sections with the chorion intact made observation of the peripheral embryonic tissue difficult, efforts were made to find some way to remove the chorion and not injure the enclosed tissue. Sodium hypochlorite would dissolve the chorion but entered the interior of the egg through the puncture and at all concentrations destroyed the tissue. However, a method was developed in which the egg was imbedded in soft plastic (Beams *et al.*, 1952) and then dissected out of it leaving the inside infiltrated but exposing the non-infiltrated chorion. The eggs were then placed in sodium hypochlorite with the object of dissolving away the exposed chorion while the enclosed tissue was protected by the infiltrant. Since it was previously known that the plastic would be removed in xylol, toluol, or acetone, the easily sectioned embryo, left when the chorion dissolved away, could then be imbedded in paraffin. Although the method proved effective in some cases where great care was exercised in dissection, in the majority of cases some disruption of the plastic could not be avoided, especially in the region of the puncture in the egg where continuity existed between the plastic enclosed within the chorion and that surrounding it. This disruption created capillary pathways for the entrance of sodium hypochlorite and subsequent destruction of at least a region of tissue around the disrupted area. However, the amount of damage was usually not great enough to prevent using the egg as a whole mount for morphological studies. The resulting pellet was transparent and could be handled and mounted with ease. If some manner of sealing the capillary pathways by which the sodium hypochlorite enters is found the method could then be used to obtain superior sections.

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NOTES ON THE BLACKFLIES (SIMULIIDAE) OF RHODE ISLAND [1]

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There have been no published notes on the blackflies in New England with the exception of O'Kane (1926) on the New Hampshire species. Johnson (1925) listed four species of blackflies from Rhode Island. Published work in neighboring localities is also limited. Twinn (1936) published on his studies in eastern Canada. Collins, Travis and Jamnback (1952) and Jamnback (1952) reported on blackfly control in the Adirondacks, in upper New York, and deFoliart (1951) wrote an unpublished thesis on the blackflies of the same region.

Data were secured by state-wide collections and by making weekly collections and seasonal history and ecological observations near Kingston for the entire year of 1952, except January, at four streams selected because they are fairly representative of the state's streams.

Some specimens were reared in the laboratory to obtain series of life history stages to facilitate identification. Rearing equipment for larvae collected in the field consisted of a five gallon aquarium filled with pond water aerated with a Marco air pump and an air stone. Around the air stone was placed a column of rocks as sites of attachment for the larvae. It was found that maximum development resulted when the pond water was siphoned off and new pond water was added about every three days. Cheesecloth was arranged in tent-like fashion over the aquarium so that adults could be collected as they emerged. The aquarium with its attachments was placed in an ice box when low temperatures were desired in order to simulate outside temperatures. Pupae collected in the field were placed on moist cotton in a shell vial. In another dry shell vial a strip of absorbent paper was placed. The vials were fastened mouth to mouth and wrapped in paper to exclude light except for a small area at the end of the dry tube. Being positively phototropic, the adults upon emergence would crawl to the dry tube where their cuticle and wings would harden normally.

Prosimulium hirtipes (Fries) was found to be the most abundant species in the state. This species overwinters in the larval stage and has one generation a year. It was found in large numbers in nearly every stream examined in all five counties of the state. Adults of this species were also the most commonly observed. Specific collection localities included Allenton, Ashton, Chepachet, Clayville, Diamond Hill, Fairlawn, Hope Valley, Kingston, Lonsdale, Manville, North Scituate, Peace Dale, Richmond, Slocum, Summit, Usquepaugh, Wallum Lake, Westerly, and West Greenwich. In the state as a whole, large larvae were collected by February 9, and by March 8, large larvae were predominant in many streams. Pupae were first collected April 3 and were last found in abundance May 13. Adults were collected from April 3 until June 14.

Near Kingston, *P. hirtipes* (Fries) was found predominantly as half-grown larvae when collections were started on February 10, 1952. Mature larvae were found

[1] The present paper is composed of portions of two Master of Science theses which are deposited in the University of Rhode Island Library. Grateful appreciation for guidance is expressed to Dr. Herbert Knutson, Head of the Department of Zoology of the University of Rhode Island for thesis direction and to Dr. Alan Stone who made some original identifications at the beginning of the study and later confirmed determinations of representative samples of collections.

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as early as March 12 and the majority of larvae were mature by April 2. Pupation was first observed on April 7, and occurred during mid-April. However, a few adults were collected April 7, indicating pupation as early as about April 1. Adults started emerging in large numbers during the second week in April and emergence continued for a week or more. After this time larvae and pupae were scarce, and were not found after May 12. Adults were not collected after May 20, except for one adult on June 14. No representatives of this species were seen thereafter until newly hatched larvae of a new, overwintering generation were observed on December 6. Although eggs were not found, it is presumed that the species spent the summer and fall in this stage. This species was found to attack man on occasion.

Prosimulium magnum D. & S. was collected only in Kingston and Allenton. In these localities it was present in most of the streams but never in large numbers. The life history of this species apparently is similar to that of *P. hirtipes* (Fries) but development appears to be a few days later.

Near Kingston, third and fourth instars were collected on March 9, and mature larvae on April 2. Larvae and pupae were collected until May 15. Pupae and adults were collected from April 23 to May 15. Larvae were not found in the fall but were probably overlooked. This species was not observed to bite.

Larvae and pupae of an undescribed species of *Prosimulium* were collected near Kingston during the study but not in sufficient numbers to determine its life history. Dr. Alan Stone had already obtained specimens of this same species from other states and the Kingston specimens were turned over to him for incorporation into his study.

Cnephia mutata (Mall.) was collected at Allenton, Chepachet, Carolina, Clayville, Diamond Hill, Hope Valley, Johnston, Kingston, North Scituate, Peace Dale, Sakonnet, Summit, Westerly, and West Greenwich. In the state as a whole, small larvae outnumbered large larvae 2 to 1 on February 9. On March 28, large larvae outnumbered small larvae 4 to 1. Large larvae outnumbered pupae 3 to 1 on April 3. Adults were first collected April 10 and the last collection was made May 9.

Near Kingston, it was found to be an abundant species especially along the coast. Its abundance was generally the result of its presence in a large number of streams rather than occurring in great densities in any one locality. In a few instances it approached and even exceeded *P. hirtipes* (Fries) in density. It is similar to *P. hirtipes* (Fries) in that it overwinters in the larval stage and has one generation a year. On February 10, larvae were mostly in the third and fourth instar. Mature larvae were not observed until April 2 but were common from that date until mid-April. Occasional mature larvae were collected until June 14. Pupae were present through April with large numbers being observed from the middle of the month until May 1. Adults were also present during this period with the emergence reaching its peak about April 23, at which time mating was commonly observed. Adults were last observed May 8. The overwintering larvae of the next year's generation were first observed on December 13 when large numbers of first and second instars were taken. The eggs were not found. This species does not appear to bite man.

Cnephia dacotense (D. & S.) was found breeding in small numbers in a few streams. At Diamond Hill it was found at a ratio of 8 large larvae to 1 pupa on April 3, 1952.

Near Kingston, two mature larvae were collected on May 8, 1952.

Simulium venustum Say was collected at Arcadia, Allenton, Beach Pond, Exeter, West Greenwich, Westerly, and West Kingston, and was the prevalent species in the state in summer.

Near Kingston, it was found to overwinter in the egg stage and to have five generations in 1952. Larvae were first

noted on March 26. Third and fourth instars were observed April 7. Growth was relatively rapid and pupation was noted April 20, and by April 23 approximately one-third had emerged. Adults were commonly observed swarming from late April until mid-June. Thereafter the generations overlapped to a large degree and all life history stages could be collected at the same time. Peaks of emergence were observed during the second and third weeks of June, the second and third weeks of July, the first two weeks of September and the first week of October. Larvae were not found after October 2, and the last pupae were found on October 25. Overwintering eggs were not found. This species is a pest of man in Rhode Island but was observed to bite rarely, during the first two generations.

Simulium quebecense Twinn was collected as a pupa near Escoheag, on April 9, 1952.

Simulium aureum Fries was collected near Kingston. Four larvae in the fourth and fifth instar were taken on May 8, and a single pupa on September 6, 1952.

Simulium decorum Walker was collected as a pupa near Kingston on May 8, 1952.

Simulium tuberosum (Lundstr.) was collected as a single, mature larva near Kingston on September 6, 1952.

Simulium vittatum Zett. was collected at Allenton, Arcadia, Diamond Hill, Hope Valley, Kingston, Lonsdale, and West Kingston. In the state as a whole, pupae were collected as early as February 21, and were taken abundantly as early as March 4. On April 3, large larvae still outnumbered pupae 5 to 3 in one locality. It overwinters in the larval stage and is a multiple generation species. It was found in larger larval concentrations than any other species. It was generally restricted to streams formed by pond or swamp outlets, commonly on or below dams or waterfalls.

Near Kingston, nearly all larvae had reached the fifth and sixth instars by February 10, although no mature larvae were found until the first of March. Pupae from the overwintering larvae were first collected about March 1, but pupae were not abundant until the end of March. By March 15, ten percent had pupated and seventy-five percent had pupated by March 26. Adults of the first generation emerged during late March and the first week in April. Throughout the spring and summer months, although the subsequent generations overlapped considerably, peaks of emergence were observed to occur during the last two weeks of May, July, and September. Larvae of the new overwintering generation hatched during the first week in October and were nearly all in the third and fourth instars by October 30. During December, many larvae developed to the fifth and sixth instars, but no mature larvae were observed. This species was not observed to bite man.

P. hirtipes (Fries) and *C. mutata* (Mall.) were present in much larger numbers in the colder streams, whereas, *S. vittatum* Zett. was much more prevalent in the warmer streams. However, since *S. vittatum* Zett. is commonly associated with pond and bog outlets, types of streams which not only maintain higher temperatures but also contain water with different chemical properties and larval foods than the colder spring-fed streams, temperature is probably not the only factor involved. *S. venustum* Say was found in both the warm and the cool streams.

P. hirtipes (Fries) was the only species found abundantly in streams which dry up during the summer.

The result of these stream preferences was the formation of definite larval associations. *P. hirtipes* (Fries) and *C. mutata* (Mall.) were commonly found breeding together. *S. vittatum* Zett. was found in nearly pure populations in its favored habitat during the winnter but in association with *S. venustum* Say during the summer. *S. venustum* Say largely replaced all the other species in the various other types of streams during the summer.

P. hirtipes (Fries) was observed to prefer stones as a site of larval attachment, whereas *S. vittatum* Zett. and *S. venustum*

Say were more often found on plant material when such was available. *C. mutata* (Mall.) showed no preference.

The economic importance of blackflies in Rhode Island is considerably less than in northern New England. Although larval densities obtained in this study were as high as 200 per square inch of infested area, average figures were never higher than 70 per square inch for any of the streams observed. These densities are not as high as those reported by other workers from more northern areas. Nevertheless, blackflies are a source of numerous complaints and more would be heard of them if it were not that residents at the present time accept them as an inescapable pest. They are locally known as "Buckie flies," since the attacks, presumably by *P. hirtipes* (Fries), coincide with the migration of the alewife, a fish known locally as the "Buckie." It was the experience of the writers that during many trips in the field from mid-April to mid-June of 1952, the head was surrounded the entire time by swarms of first one and then the other of the two major species, *P. hirtipes* (Fries) or *S. venustum* Say. The number varied from 5 to 150 adult females. These swarms themselves constituted a considerable nuisance, and in addition, flies frequently landed on the skin and occasionally bit. Of the insects of medical importance in the state, they rank far behind the mosquitoes but ahead of the punkies (Heleidae) and deer flies (Tabanidae). The principal sufferers are the trout fishermen since the trout season in Rhode Island closely parallels the blackfly season. Early gardeners and golfers are also plagued by blackflies.

Summary.—Geographical and seasonal history data obtained from various places over the state are presented.

At Kingston, collections made weekly at four selected streams throughout 1952 resulted in seasonal history pictures of five of the more common species:

Prosimulium hirtipes (Fries) was the most abundant species. It was predominantly a half-grown larva on February 10. Most larvae were mature by April 2 and pupation occurred predominantly during mid-April. Adults emerged in large numbers during the second week in April and continued a week or more. Adults had virtually disappeared by May 20. Overwintering larvae were first observed December 6.

P. magnum D. & S. never was taken in large numbers. Its seasonal history is similar to *P. hirtipes* (Fries) but development is apparently a few days later.

Cnephia mutata (Mall.) was abundant as the result of its occurrence in a wide variety of streams rather than local high densities. Larvae occurred until mid-April and thereafter in small numbers until until June 14. Pupae were present during April, especially during the last half of April. Adult emergence reached a peak about April 23. Overwintering larvae were first observed December 13.

Simulium venustum Say underwent five generations in 1952 in the area studied. Larvae were first noted March 26. Pupation occurred during the last two weeks in April with first generation adults emerging during that period. Subsequent emergence peaks were noted during the second and third weeks in June, the second and third weeks in July, the first two weeks of September and the first week of October. Larvae were not found after October 2.

Simulium vittatum Zett. underwent four generations in 1952 in the area studied. Nearly all larvae had reached the fifth and sixth instar by February 10, although no mature larvae were found until March 1. Pupae were abundant by the end of March. Adults emerged during late March and early April. Subsequent emergence peaks were noted during the last two weeks of May, in July, and in September. Overwintering larvae hatched during the first week in October.

Cnephia dacotense (D. & S.), *Simulium decorum* Walker, *S. tuberosum* Lundstr., *S. aureum* Fries, *S. quebecense* Twinn, and one undescribed species of *Prosimulium* were collected in small numbers.

P. hirtipes (Fries) and *C. mutata* (Mall.) larvae and pupae developed together primarily in the colder streams during winter and early spring. *S. vittatum* Zett. larvae and pupae occurred in nearly pure populations in the relatively warm lake and bog outlets during the winter but in association with *S. venustum* during the summer. *S. venustum* Say larvae and pupae occurred in practically all types of streams during the summer, at which time the other species were generally scarce or absent.

P. hirtipes (Fries) is the most important pest series. *S. venustum* Say is also of some importance. While control is feasible under some circumstances, blackflies by no means attain the economic importance in Rhode Island that they do in northern New England.

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SOME BIOMETRICAL CONSTANTS FOR *ANOPHELES QUADRIMACULATUS* SAY LARVAE IN RELATION TO AGE WITHIN STADIA

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The present writer has found only one paper giving size measurements on *Anopheles quadrimaculatus* larvae, that of Abdel-Malek and Goulding (1948) on head capsule widths.

In physiological and toxicological experiments on *A. quadrimaculatus,* some means of estimating the age of larvae within a given stadium was needed, for it had been observed that larvae from the same egg batch grew at different rates under uniform conditions. To determine larval age, measurements of total body lengths, thoracic widths, "collar" lengths, and head capsules were made. Measurements were also made on eggs.

Grateful acknowledgment is made to Mr. J. L. Scheltema for a great amount of expert assistance.

Methods. All studies were made on material from a heterogeneous colony of *A. quadrimaculatus* Say (Diptera: Culicidae).

Eggs laid during the night were collected the next morning, measured in a film of distilled water on a slide at 75 diameters, and placed in 20 ml. of distilled water in numbered, filter-paper-lined petri dishes for hatching at 28 to 30° C. The larvae were fed daily on a 1:1 mixture of dog food and brewer's yeast until they pupated. Larvae took from 1–3 days to complete each of the first 3 stadia and from 2–4 days to complete the fourth stadium. Many larval measurements were made on living specimens to permit daily observations on single individuals of known history. At first, larvae were measured while floating in water in micro slides. Since this proved very inconvenient, larvae were placed in drops of distilled water on ordinary glass slides and all but a thin film of water removed with filter paper strips prior to measurement at magnifications of 6.6 to 75 diameters. For studies on first instar collar lengths alcohol-fixed material was examined at 750 diameters.

Definition of Terms. 1. Head capsule width: The widest portion of the head capsule, between the larval eyes, was measured.

2. Collar length: The posterior rims of the epicranial plates form a collar-like piece around the posterior end of the head. This structure was referred to by Smith (1914) in her beautiful study of *Anopheles punctipennis* as the collar. The collar grows progressively in length during each of the first 3 stadia. It is clearly a part of the head, for it is shed with the cuticle of the latter at each molt. The anterior to posterior dimension of the dorsal portion of the collar was measured.

3. Total head length: Includes both the growing collar region and the non-growing portion of the head anterior to it (precollar region).

4. Thoracic width: The widest portion of the thorax, the mesothorax, was measured.

5. Total body length: The distance from the anteriormost portion of the frontoclypeus to the anus was considered as the total body length. This measurement excluded mouth brushes and anal papillae. All measurements were made along the mid-dorsal line.

Results. The various egg dimensions of *Anopheles quadrimaculatus* were found to be remarkably constant. The constancy of the figures (Table 1) suggests that there are no size differences between male and female eggs.

Mean head capsule widths and the ranges in total body lengths for the four instars of *A. quadrimaculatus* are given in Table 2. Variations in head capsule widths for each stadium and their frequencies are graphed in Fig. 1. The relation between the mean head capsule widths and total body lengths is shown in Fig. 2.

The values in Table 2 differ slightly but, nevertheless, significantly from those given by Abdel-Malek and Goulding (1948). While their data actually showed that the greatest proportionate differences (ratio of mean head capsule width of one instar to the next) in head capsule widths occurred between the second and third stadia, they concluded from other information that this was due to an experimental error in measurements, and that it should have occurred between the first and second stadia. The data in Table 2 confirm their conclusions and correct their experimental error.

The range in total body length measurements for a given stadium overlaps that of the preceding stadium (Table 2) as a result of different growth rates, but the

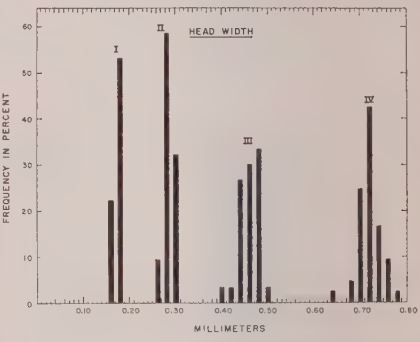

FIG. 1.—Frequencies in head capsule width variations for each of the instars of *A. quadrimaculatus*.

TABLE 1.—Mean dimensions of 25 eggs of *Anopheles quadrimaculatus* Say

Part measured	Mm.	S.E.	SD
Total egg length	0.56	0.004	0.019
Anterior (top) width	0.14	0.002	0.01
Center width (including floats)	0.21	0.002	0.01
Depth (dorso-ventral dimension at egg center)	0.14	0.001	0.01
Posterior (bottom) width	0.11	0.002	0.01
Float length	0.29	0.004	0.02
Float width	0.09	0.016	0.01

TABLE 2.—Mean head capsule widths and total body lengths for the four instars of *Anopheles quadrimaculatus*

	Head capsule width*				Total body length			
Instar	No. measurements	Width (mm.)	SD	Capsule ratios	No. measurements	Length Min.	Length Max.	Magnif.
I	75	0.174†	0.009		125	0.7	1.7	30 x
				1.638				
II	53	0.285†	0.012		98	1.4	3.0	30 x
				1.611				
III	60	0.459‡	0.019		104	2.5	5.6	13–30 x
				1.569				
IV	85	0.720	0.025		190	3.3	7.6	6.6–13 x

* All measurements at 75 x.
† Values differ from those of Abdel-Malek and Goulding, (1948) by +0.016.
‡ Value is 0.009 less than Abdel-Malek and Goulding reported.

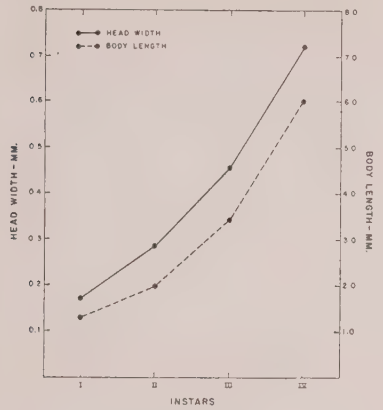

FIG. 2.—Relation between mean head capsule widths and mean total body lengths in the larval stage of *A. quadrimaculatus*.

mean total body lengths are different for each stadium. Increases in total body length occur at the beginning of each new larval stadium. For example, immediately after molting to the fourth stadium total body lengths increased 0.1 to 0.4 mm. (mean increase 0.23 mm.). A decrease in length is seen prior to pupation. Since body lengths overlap within a given stadium, they do not permit estimations of age within it; the same is true for thoracic widths.

Immediately after hatching the collar is either not present or only faintly indicated (Fig. 1, Plate I). Shortly thereafter it becomes clearly defined but does not completely encircle the head. Later as the collar lengthens it forms a continuous band around the base of the head (Fig. 6A, Plate I). The fully formed collar is made up of 3 distinct zones: (1) a dark anterior rim, (2) an intermediate tan zone, and (3) a terminal clear zone.

Since the collar undergoes changes in length within each of the first 3 stadia, while that portion of the head anterior to the collar (pre-collar region) undergoes no change in dimensions, it is possible not only to identify an instar by capsule width but to determine its age by collar length. Collar lengths in first instars grow from approximately zero to 0.066 mm. (Table 4). Since almost every intermediate between these two extremes can be found, the growth is considered continuous. Measurements of collar lengths of larvae at different periods within the third stadium (Table 3) furnish a means of roughly estimating age to the nearest quarter of the stadium.

Observations on darkening of the head capsule and pigmentation of the palmate hairs also permit rough estimation of larval age. The head capsules of newly

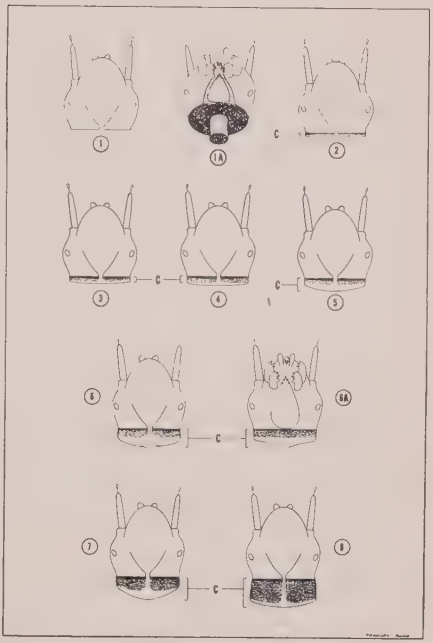

Plate I.—Development of the collar (c) in first instars.

Fig. 1.—Dorsal view of head of 2 hour old larva.
Fig. 1A.—Tipped ventral view of head of 2 hour old larva showing that the "collar" does not encircle the head.
FIG. 2.—Dorsal view of head of 7 hour old larva.
Fig. 3.—Dorsal view of head of 10 hour old larva.
FIG. 4.—Dorsal view of head of 18 hour old larva.
Fig. 5.—Dorsal view of head of 22 hour old larva.
FIG. 6.—Dorsal view of head of 30 hour old larva.
Fig. 6A.—Ventral view of head of 30 hour old larva.
Fig. 7.—Dorsal view of head of 34 hour old larva.
Fig. 8.—Dorsal view of head of 40 hour old larva.

TABLE 3.—Measurements of collar length, thoracic width, and body length in third and fourth instar *A. quadrimaculatus* *

Part measured	Instar	Range in dimensions (mm.) at different periods within stadium			
		First quarter	Second quarter	Third quarter	Fourth quarter
Collar length	III	0	0-0.04	0.03–0.09	0.08–0.10
	IV	—	—	—	—
Thoracic width	III	0.6 –0.7	0.7–0.9	0.7 –1.1	0.9 –1.1
	IV	1.05–1.30	1.2–1.45	1.3 –1.55	1.4 –1.55
Total body length	III	2.2 –3.2	2.8–4.0	3.2 –4.0	3.6 –4.4
	IV	4.0 –6.5	4.8–5.9	5.7 –6.2	5.5 –5.7

* Data based on measurements from 10 III instars and 10 IV instars.

hatched or molted larvae are always very light in color. In the third stadium the head capsule is very light during the first quarter, light tan to brown in the second quarter, and either tan or dark brown during the third and fourth quarters. Palmate hairs in the first stadium are single, thin, colorless, spindle-shaped structures; they remain clear in the second stadium and become pigmented first in the third stadium (usually only those on segments III–V are darkly pigmented). The palmate hairs are very light or just beginning to become pigmented in the first two quarters of the third stadium. As is well known, pigmented palmate hairs occur on segments II/III–VII in fourth instars. In the fourth stadium the palmate hairs are fully pigmented after the first quarter.

TABLE 4.—Changes in collar length during the first stadium of *A. quadrimaculatus* (10 larvae measured at each age)

Hours old	Range in collar length (mm.)	Mean collar length
2	0–0.006	0.003
7	0.002–0.008	0.005
10	0.004–0.010	0.006
14	0.006–0.014	0.009
18	0.011–0.024	0.015
22	0.014–0.030	0.024
26	0.020–0.030	0.026
30	0.020–0.048	0.030
34	0.026–0.060	0.039
40	0.034–0.066	0.052

Some additional observations not pertaining to age estimation are of interest. The so-called "notched organ" of Nuttall and Shipley (1901) is not at all notched in the first instar. There is no ventral brush on the anal segment in the first instar although the region from which it will form is clearly indicated. The imaginal compound eye disc first becomes apparent at the beginning of the third stadium. Green, pinkish, brown, and mixed pigmentation of larvae becomes evident only in the fourth stadium.

DISCUSSION. Measurements on eggs of *Anopheles quadrimaculatus* given in this paper are generally quite comparable to those reported for a number of other species of *Anopheles* (Smith, 1914; Sweet and Rao, 1939; Bellamy and Repass, 1950). There appear to be no measurements on egg depths in the literature on *Anopheles* mosquitoes.

The head capsule width of *A. quadrimaculatus* larvae in a given stadium is fixed as is the length of the head anterior to the collar, but the total head length progressively increases within each of the first 3 stadia due to development of the collar.

Immediately after a molt the new head capsule has no collar and the length of the new capsule is found to be almost the same as at the end of the preceding stadium. The new head capsule is continuously formed underneath the old one and extends underneath the collar. While it

is true that the change in head capsule widths from one stadium to the next appears discontinuous, the growth responsible for the change has been continuous. In other words, the formation of a new head capsule is not the result of explosive cellular divisions at the molt but rather is the result of a gradual growth throughout the given stadium and is made manifest at the molt by an expansion in width. There do not, then, appear to be periods when true growth is entirely absent in the development of the head capsules of the first 3 stadia of *A. quadrimaculatus*.

Mitrofanova (1929) made measurements on the collars and pre-collar head lengths of *Anopheles maculipennis* larvae and referred to the progressive growth of the collars, but she did not use this information for determination of age within a stadium. She found that the total head length between stadia always increased slightly at the molt.

Summary. 1. The following biometrical constants were obtained for *Anopheles quadrimaculatus* Say: Mean measurements of length, anterior width, center width, posterior width, depth, float length and width for the eggs; mean head capsule widths and ranges in total body lengths for the four stadia.

2. A region posterior to and continuous with the epicranial plates of the larval head capsule was found to grow continuously within each of the first three stadia. This region of the head capsule is referred to as the collar.

3. Approximations of age within the first 3 stadia can be made by measurements of collar lengths alone.

4. Darkening of the head capsule and pigmentation of the palmate hairs are helpful in age approximation of larvae.

5. Thoracic widths and total body lengths overlap within stadia and therefore do not permit determination of approximate ages.

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DESPLAINES VALLEY MOSQUITO ABATEMENT DISTRICT

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PHOTOMICROGRAPHY OF MOSQUITOES WITH THE SINGLE-LENS REFLEX CAMERA [1]

GEORGE J. BURTON, PH.D.[2]

The writer has done a considerable amount of photomicrography of the various stages of mosquitoes with the single-lens reflex 35 mm. camera known as the "Practica FX," manufactured by the Kamera-Werkstatten (KW-Optik Works), Dresden, Germany. All procedures described herein are based on experiences with the Practica, but, since all single-lens reflex cameras work on the same principle, it is probable that very good results may be obtained with other such cameras.

In a single-lens reflex camera, the image formed by the lens is photographed right side up. A mirror, set at an angle of about 45 degrees, reflects the entering light upon a rather large ground-glass focusing-viewing screen, hence the name "reflex." The focusing screen in the Practica measures 24 x 36 mm. The film runs along the back of the camera, directly behind the mirror. A large hood surrounding the screen permits better viewing, and the picture is seen in full brilliance.

The single-lens reflex camera is free from parallax regardless of the distance from the subject, because both the viewing and taking are performed by the same lens. When the camera is mounted on a microscope, the photographer looks horizontally at the screen. A hinged-on magnifying glass permits critical focusing of the reflex image.

The Practica has the following shutter speeds: 1/500, 1/200, 1/100, 1/50, 1/25, 1/10, 1/5, and 1/2 second. A "B" setting, which is ordinarily used for taking flash pictures, permits speeds less than 1/2 second. The Practica can be put to very good use by the entomologist who is interested in photographing the different stages of mosquitoes on 35 mm. film. Superb Kodachrome slides, as well as good black and white pictures, may be obtained with a little experience.

The photo-micro attachment for the Practica is the same as that used for the Exacta, except that an adapter ring is added to fit the Practica. Since the camera lens is not used, the lens mount is unscrewed and removed from the camera, thereby avoiding the necessity for adjusting the lens opening.

After the camera is in place, any necessary adjustments as regards the picture frame and focusing can be accomplished by viewing the reflex image on the focusing screen.

Low-power objectives and oculars are very useful in taking pictures of entire eggs, egg rafts, larvae, pupae, and adults. Any compound monocular microscope having a substage condenser can be used. First, the ocular is removed; then the un-

[1] The material presented herein in no way constitutes an endorsement by the Department of Defense.

[2] At the time this paper was submitted, Entomologist, Engineer Research and Development Laboratories, Fort Belvoir, Virginia; now Lt. Commander in U. S. Public Health Service, FOA, American Embassy, Monrovia, Liberia.

Editor's note: The editor felt that Dr. Burton's manuscript as originally submitted could be shortened and made of more specific interest to mosquito control workers if certain details, e.g., a discussion of lenses, were omitted. Other reviewers shared this opinion and were also agreed that other details, which can be found in manuals of photography, could well be omitted in the interests of economy. The editor obtained permission from the author to make certain deletions, and then went on to make a few more, shortening the manuscript by nearly half. Unfortunately, Dr. Burton is now in Liberia, and could not be consulted on these changes, for which the editor must therefore accept full responsibility. The editor feels that the chief value of the paper is to those persons who are interested in mosquitoes but who are not necessarily experienced photomicrographers and that in giving instructions which are obviously the results of many painstaking trials, the paper will save other workers much of the time that is ordinarily spent in such trials.—D.L.C.

hinged photo-micro attachment is slipped over the body tube for a short distance, and the holding screw is tightened. The ocular is replaced, and the hinged portion is fastened. The camera body may be screwed on either before or after this procedure. A microscope lamp having at least a 100 watt bulb is placed directly in front of the mirror, so as to permit a maximum amount of light to pass through the microscope.

For black and white photography, a film having a fast or a slow film speed rating may be used, and the exposure time varied accordingly. The writer prefers to use a film having a B.S. and A.S.A. Arithmetic Index rating of 50, such as the Kodak Plus-X (PX 135), which is a fast, fine-grained, panchromatic safety film. Its equivalents are B.S. and A.S.A. Logarithmic Index 28°, European Scheiner 29°, DIN 18/10°, Weston Speed 40, G.E. Speed 64, and Hurter and Driffield 2000. Slow film rated less than 50 B.S. and A.S.A. Arithmetic Index may be used, if desired.

No light meter is used in photomicrography as described here. When using Plus-X film, if the subject on the slide is neither too dark nor too light, the picture is taken at a shutter speed of 1/50 second. If the subject is somewhat darker than average after the light is transmitted through it, the exposure should be from 1/25 to 1/2 second. Since a cleared or entire specimen of any particular species has a yellowish or brownish pigmentation, the shutter speed will have to be varied accordingly. The beginning photographer will have to practice on several rolls of film, keeping accurate notes for each picture taken. For each picture snapped, there should be noted the genus and species of the specimen, the life history stage involved, the shutter speed used, the magnification at which the picture was taken (ocular multiplied by objective), and whether or not certain filters were used. Then, after the pictures have been developed, each photograph should be compared with the detailed data previously taken, and the particular slide studied again. Thus, after several rolls have been taken, the photomicrographer will have a very good idea of the type of lighting, shutter speed, and the best magnification to use with any particular specimen.

For detailed studies at high power, one may enlarge portions of photographs taken at lower powers, but much better results will be obtained by actually photographing the particular structure under high magnification at the outset. For instance, one may photograph an entire culicine larva under low power, then enlarge the posterior segments so as to show the pecten under a high magnification. Since the light being transmitted is decreased with increase in magnification, the shutter speed will have to be decreased as the lighting is decreased, taking into consideration the pigmentation of the specimen. Thus, referring to the example cited, if pecten teeth are photographed under 100X to 440X, the shutter speed might be set at 1/50 to 1/2 second, depending on the general light intensity at the high magnification, as viewed on the focusing screen.

Considerable use should be made of the hinged-on magnifier, which is flipped into position with a flick of the finger. This lens is quite powerful for its size, and by looking through it the subject on the focusing screen below the magnifier is seen in great detail. The fine adjustment is turned while the photographer looks through the magnifier, until the subject is seen at its sharpest setting. The magnifier may then be flipped back to its original position. The shutter is then released. A cable release is very valuable for releasing the shutter at the exact moment desired, so as to avoid moving the camera.

Since the various life history stages of mosquitoes vary in color from pale yellow to deep orange, brownish orange, or brown after being mounted on slides, yellow and blue filters may be used to good advantage. In order to obtain better detail, use a filter of the same color as the preparation, while to obtain contrast use a filter of a complementary color. Filters

of intermediate color may produce a useful compromise.

Filters may be home-made of colored glass, colored cellophane, colored inks, or colored chemical solutions, or else regular commercial filters may be purchased. When using a dilute chemical solution or dilute colored ink, the liquid should be placed in an 8-ounce flat prescription bottle, which is then placed between the light source and the mirror. Dilute methylene blue, copper sulfate, or blue ink will produce blue filters of any intensity desired; try them in ½ percent to 2 percent solutions to see results obtained. Yellow filters are made by using a 2 percent picric acid solution, ½ percent naphthol yellow solution, 10 percent potassium chromate, 10 percent potassium dichromate, or dilute yellow ink. An orange filter is made by using a 2 percent Orange G solution and a variation toward the red by using 2 percent eosin. A red filter may be produced by using 2 percent magenta red, carmine, Congo red, or dilute red ink.

When using a commercial, mounted filter, the most convenient position for it is below the stage; if necessary it may be placed over the mirror. If the filter is merely a glass disk, it should be slipped into the slot which is made to hold a filter, in the substage apparatus.

Insect preparations usually give more satisfactory photomicrographs when yellow, orange, or red filters are used, since the details stand out very well. When a blue filter is used, a contrast is produced, so that certain organs and fine markings stand out very sharply. The entomologist may check the effect of filters by using them while studying mounted specimens during routine work.

It is suggested that the beginner carry out the following procedures in order to learn quickly the fundamentals of photomicrography of insect preparations. Select an excellent slide of a culicine larva, complete in every detail and of medium yellow intensity, and set the posterior end under a magnification which will enable all details of the 8th and 9th segments to be seen on the focusing screen. Without using any filter, photograph this view in sequence at the following speeds: 1/100, 1/50, 1/25, 1/10, 1/5, and 1/2 second. Then repeat this sequence, using a yellow filter; repeat using a red filter; and finally repeat while using a blue filter. Have the film developed and make 3 x 4 inch prints, or 5 x 7, if the photographer is doing his own developing. Remember to keep accurate notes, so as to identify each print properly. On each print, write the appropriate data concerning speed and filter. Now lay out all the prints, and study them carefully. The amateur will learn more about photomicrography in this manner than by any other system of guess work. If a very light colored and a very dark colored microscopic preparation are available, the entire procedure may be repeated, if desired. After a while the photomicrographer will be able to look at any preparation and know just what kind of filter to use, if any, and the best shutter speed to use, so as to bring out the most detail. It must be re-emphasized that the color of the preparation at the desired magnification is the key to determining which speed and which filter (if any) are to be used. Many pictures can be taken without using filters at all, if the preparation is a good one.

Kodachrome transparencies of mosquito preparations usually come out very well when a few simple rules are followed. Daylight Type film (K135) is used. Since the film speed rating is only 10, the shutter speed must be less than that used with Plus-X black and white film. Excellent results are usually obtained at 1/25 second when an average subject is photographed, but darker preparations may necessitate 1/10 to 1/5 second. A very light subject will necessitate using 1/50 second. A yellow, orange, or red filter will bring out many details, and should be selected according to the color of the preparation. A blue filter is of no value in color photomicrography when using Daylight Type film, as the entire preparation will then come out blue.

A very important thing to remember is that various scales, teeth, and hairs are in

different planes; consequently, not all such structures will stand out in any one field. It may be necessary to take photographs at different levels or planes if pictures of such structures are desired. Critical focusing with the aid of the hinged-on magnifier will ensure sharpness of the image.

Fig. 1.—Head of *Anopheles maculipennis,* 1/50 of a second.

Fig. 2.—Larva of *Aedes dorsalis,* 1/25 of a second, yellow filter.

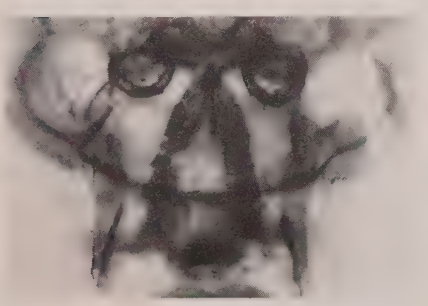

Fig. 3.—Spiracle of larva of *Anopheles maculipennis,* 1/50 of a second, 150 x.

When using an ocular and an objective of very low power simultaneously, the lighting is often distorted, due to the inherent nature of the 3.5X and 2.5X objective and to the height to which the body tube must be raised when using such objectives. The light becomes concentrated in the very center of the preparation. This phenomenon can be remedied by removing the substage condenser, so that the light is not too concentrated.

All of the procedures described above pertain to photomicrography through the compound monocular microscope, making use of transmitted light. Let us now consider the use of the stereoscopic dissecting microscope.

If a dissecting microscope is mounted on a mirror-bearing base, light may be either transmitted or reflected. When the opaque metal plate, which is ordinarily in position beneath the glass stage, is removed, the subject on the slide is viewed by transmitted light as with the compound microscope. The photo-micro attachment may be affixed either to the left or to the right tube, and the camera will then be set at an awkward angle. In this way, the subject may be photographed as heretofore described, but results are not quite as sharp as when the compound miscroscope is used. It is not necessary to cover over the ocular which is not in use. The low-powered stereoscopic microscope permits photography of an *entire* larva, pupa, or adult.

If the white plate is slipped into position, an entire adult mosquito may then be photographed by means of reflected light from above. This light must be very strong and intense, otherwise the image appearing on the focusing screen will be too dark, and the picture will not come out. The adult may be mounted on a pin, and the pin thrust into a cork so as to bring the specimen into the position desired; else the specimen may simply be laid upon the stage. A lower shutter speed is necessary for such cases, due to the diminished lighting, consequently, it will be necessary to use speeds of 1/10, 1/5, 1/2 or 1 second, or more. Use the same procedure of photographing sequences at different

speeds, as already described, in order to see what the results are at the various speeds under this particular method of lighting.

Pinned adults may be photographed without the microscope if a series of extension tubes is on hand. The addition of special close-up lenses will shorten the focus. When using extension tubes, it is necessary to increase the exposure time as registered on a standard exposure meter. An exposure meter should always be used for taking pictures other than through the microscope.

MOSQUITO SURVEY OF HORN ISLAND, MISSISSIPPI

ROY W. RINGS [1] AND E. AVERY RICHMOND [2]

Entomological surveys in connection with insect control activities were initiated at Horn Island Installation, Mississippi, in February, 1944, and were continued through July, 1945.[3] Considerable data were accumulated during this period on the insect fauna of Horn Island, including prevalence, seasonal distribution and breeding habitats of various species of mosquitoes. A summary of the mosquito surveys is presented as a further contribution to previously published accounts on the distribution of mosquitoes in the southeastern states. Although all species recorded in Table 1 have previously been reported from the state of Mississippi, only two species have been reported from the island chain just off the coast of Mississippi. These represent collections from Ship Island as follows: *Anopheles atropos* by Komp (1926) and *Aedes taeniorhynchus* by Dyar (1926). An examination of the records of the Fourth Service Command Medical Laboratory revealed several unpublished records that were submitted as miscellaneous collections from these islands. The collections are listed by species, number collected, type and date of collection and locality. The symbols in parentheses indicate the types of collection; (L) larval and (R) resting station: *Aedes sollicitans,* 22 (L) February 23, 1945, Ship Island; *Aedes vexans,* 1 ♂ (R) February 24, 1945; and 1 (L) February 23, 1945, Ship Island; *Anopheles crucians,* 3 (L) June 2, 1943, Cat Island; *Anopheles bradleyi,* 3 (L) June 2, 1943, Cat Island; *Culex salinarius,* 7 (L) February 23, 1945, Ship Island; *Culiseta inornata,* 42 (L) February 23, 1945, Ship Island.

Horn Island Installation occupies a central position on Horn Island which is located in the Gulf of Mexico approximately six to eight miles from the coast of Mississippi near Pascagoula. The island is twelve miles in length, varies from one-fourth to three-fourths of a mile in width and in shape resembles a slightly curved horn. The terrain is low and sandy with the exception of the longitudinal central portion which is slightly higher in elevation and covered irregularly by small groves of slash pine *(Pinus caribaea).* Several large lagoons and many smaller

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[3] These surveys were conducted under the general supervision of the Special Projects Division of the Chemical Warfare Service. It is desired to express sincere appreciation to Lt. Col. Stanley J. Carpenter, Dr. Woodrow W. Middlekauff and Mr. Virgil I. Miles; to Dr. Alan Stone of the U. S. National Museum and to personnel of the U. S. Public Health Service, Atlanta, Georgia.

TABLE 1.—Mosquito species collected on Horn Island, Mississippi, in 1944 and 1945 arranged according to prevalence, numbers, months in which collected and collection methods *

Species	Number of specimens collected 1944	1945	Months in which collected and collection methods
Aedes sollicitans	1,801	10,782	Feb.–Nov. (T) (B) (L) (F) (H)
Culex salinarius	5	977	Feb.–Nov. (T) (B) (L) (F) (H)
Anopheles atropos	90	491	Feb.–Sep. (T) (B) (F) (H)
Anopheles crucians-bradleyi	277	181	Feb.–Nov. (T) (B) (F) (H)
Aedes taeniorhynchus	86	176	Apr.–Oct. (T) (B) (L) (F) (H)
Culex sp	158	93	July–Nov. (T)
Culex quinquefasciatus	179	0	Feb.–Nov. (T) (F) (H)
Uranotaenia sapphirina	35	94	March–Oct. (T) (L) (H)
Aedes vexans	17	105	March–Nov. (T) (F) (L)
Culiseta inornata	78	1	Oct.–Mar. (T) (L) (F)
Psorophora ciliata	27	20	Apr.–Aug. (T) (L) (F)
Uranotaenia lowii	43	0	Aug.–Nov. (T) (L) (H)
Psorophora howardii	1	29	Apr.–July (L) (B)
Psorophora confinnis	2	18	Feb.–June (L) (H)
Anopheles bradleyi	0	8	May (L)
Culex pilosus	6	0	Aug. (T)
Aedes mitchellae	4	1	Feb.–Oct. (T) (H)
Aedes infirmatus	0	4	Apr.–July (T) (L)
Culex restuans	3	0	March (L)
Psorophora discolor	0	2	May–July (T)
Psorophora sp	2	0	Aug. (L)
Aedes atlanticus	0	1	Apr. (L)
Aedes atlanticus-tormentor	1	0	Sep. (H)
Anopheles crucians	0	1	May (L)
Anopheles quadrimaculatus	1	0	Oct. (F)
Culex erraticus	1	0	Aug. (T)
Culex nigripalpus	1	0	Aug. (T)
Culex apicalis	1	0	Apr. (L)
Psorophora ferox	0	1	June (B)
Aedes aegypti	†	0	March †(Eggs)
Totals	2,819	12,985	

* Symbols for collection methods are as follows: (T), New Jersey type electric light trap; (L), larval; (F), fly trap; (B), biting; and (H), hand-collected.

ones are present. They are usually surrounded by marshes. The climate is subtropical with approximately 60 to 70 inches of rainfall annually. Prevailing winds are southerly with occasional periods of northerly winds.

The methods and frequency of collections varied somewhat for the two-year period. In 1944, the New Jersey light trap was usually operated only on Wednesday night of each week while in 1945, light trap collections were made each night. Twelve box-type resting stations measuring 2½′ x 1½′ x 1½′ were installed in March 1945. Although these stations were visited weekly from April to August, no mosquitoes were found in them during this period. This would indicate that those species commonly found in resting stations, such as *Anopheles quadrimaculatus, Culex quinquefasciatus, Culex restuans,* and *Culex (Melanoconion)* species, were absent or scarce during this period. Biting collections were made from March to August 1945 and were obtained by capturing all insects attempting to feed upon the collector during a ten minute period at each of ten designated biting stations. Special field trips were made in 1944 for the collection of biting or resting adult mosquitoes by the cupped vial method, and by sweeping nets. Numerous

field trips were involved in both 1944 and 1945 in collecting immature forms of mosquitoes for the purpose of sampling the larval populations and also as a check on control measures. Fly traps were operated from April, 1944 to August, 1945 primarily to sample the populations of house-frequenting flies and stable flies but incidentally trapped many mosquitoes. A standard molasses-yeast bait was used in the fly traps and weekly collections recorded.

Twenty-six species of mosquitoes are now known to occur on Horn Island. These are listed in Table 1 in order of abundance, months in which they were collected and methods of collection. Ecological notes on prevalence, seasonal distribution and breeding habitats on the more important species are as follows:

Aedes sollicitans (Walker). This species is by far the most abundant and troublesome species occurring on the island. It was predominant in all types of collections and comprised 63.90 percent of the total mosquito collections in 1944 and 83.38 percent of the collections in 1945. *A. sollicitans* larvae were most frequently encountered in low marshy areas and depressions which were inundated only at certain periods of very high tides. These areas for the most part are covered with the common reed, *Juncus robustus*. Observations on the flight habits of the adults in both years indicated that sudden and tremendous rises may occur in the adult population while the larval population remains extremely low. Such increases are apparently preceded by northerly winds and it is believed that such flights represent migrations from the marshy coast of the mainland six to eight miles to the north. *Aedes sollicitans* adults were encountered throughout the year but reached a peak abundance during July and August.

Culex salinarius Coquillet was second in prevalence for the two-year period but the species was of minor importance in causing discomfort to troops. *C. salinarius* adults appeared throughout the year 1944 but reached their maximum numbers during April. Comparatively few *salinarius* were collected in 1944 as compared with 1945. Larvae were collected in saline pools in association with *Aedes sollicitans* and to a lesser extent in small freshwater pools.

Anopheles atropos Dyar and Knab was the predominant anopheline in 1945 but was collected in smaller numbers than *crucians-bradleyi* in 1944. Females of this species are readily attracted to light at night and were observed to bite occasionally during the afternoon in shady woods. Adults of this species were collected from March to August but were encountered most frequently in midsummer.

Anopheles crucians-bradleyi. The nomenclature *crucians-bradleyi* is used here to designate a consolidation of the two species since there is, to date, no published account of an exact procedure to differentiate the adults of the two species. King (1939) has given characters for separating some *bradleyi* from *crucians* but it is believed that separation of the two species on this basis would not represent a true proportion of the two species. Out of the eight larvae of the *Anopheles crucians* group collected on Horn Island, seven were identified and verified as *bradleyi* and one specimen was *crucians*. Six large anopheline larvae collected on Cat Island, Mississippi, on June 2, 1943, were submitted to the 4th Service Command Medical Laboratory for identification. Three of these specimens were *bradleyi* and three *crucians*. Although such figures are too small to base an estimate of the true proportion it is the opinion of the authors that *bradleyi* makes up a greater proportion of the *crucians-bradleyi* than does *crucians*. Both species were collected as larvae from slightly brackish pools.

Aedes taeniorhynchus Wiedemann is similar in habits and seasonal prevalence to *A. sollicitans* but did not occur in sufficient numbers to be troublesome.

Culex quinquefasciatus Say occurred quite frequently in light trap collections throughout 1944 and upon one occasion was discovered breeding in a fire barrel.

The species was absent in 1945 with the exception of one female captured aboard a small aircraft rescue boat from Pascagoula which had recently docked at the island. The absence of this species in 1945 may be explained by two factors, (a) sanitary measures initiated in 1944 were rigidly enforced during the latter part of 1944 and 1945, and (b) screening on all buildings within the camp area was treated each month with a solution of 5 percent DDT in oil from July, 1944, to August, 1945. Considering the domestic habits of this species, it is quite probable that the residual toxicity of treated screens has more effect on populations of this species than on other mosquito species of a less domestic nature.

Two species of "gallinippers" *Psorophora ciliata* and *P. howardii* were abundant and troublesome during certain periods from April to August of both years. The adults were observed to be severe biters and were usually accompanied by *Aedes sollicitans*. The larvae were collected from freshwater pools where they were associated with *Aedes vexans* and *Psorophora confinnis*.

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PICTORIAL KEYS TO THE MOSQUITOES OF MEDICAL IMPORTANCE IV. ANGLO-EGYPTIAN SUDAN

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The accompanying keys are the fourth in a series being prepared under a transfer of funds by the Department of the Army to the Bureau of Entomology and Plant Quarantine. They are designed primarily to assist public health workers in rapidly separating and identifying the mosquito species of primary medical importance in various regions throughout the world. The keys are so constructed that they separate the important species not only from each other, but also from all others known to occur in the area concerned. The keys are presented (see also *Mosquito News,* Vol. 13, Nos. 1 and 2, 1953) in the hope they may elicit suggestions and comments, especially from persons having first hand information about the faunas or diseases of the areas concerned.

Anopheles gambiae, the most important

MOSQUITOES OF MEDICAL IMPORTANCE — ANGLO-EGYPTIAN SUDAN

FULL-GROWN LARVAE

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

INSECT IDENT. BEPQ. USDA UNDER FUNDS ALLOTTED BY SECRETARY OF ARMY APRIL 1953

NO SIPHON ON *ANOPHELES*

ABDOMINAL PLATES 4 TO 7

COVERING LESS THAN 1/2 OF SEGMENT

COVERING ABOUT 1/2 OF SEGMENT

LONG PLEURALS OF 3RD GROUP

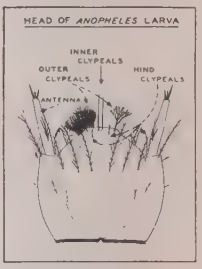
BOTH BARE + OUTER CLYPEALS (NOT) = *ANOPHELES NILI*

ONE HAIRED + PROTHORACIC HAIR 1 (NOT) = *ANOPHELES GAMBIAE*

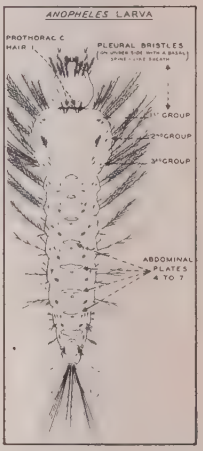
BOTH HAIRED + OUTER CLYPEALS (NOT) = *ANOPHELES RUFIPES*

= *ANOPHELES FUNESTUS*

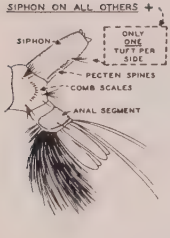
HEAD OF *ANOPHELES* LARVA



ANOPHELES LARVA



SIPHON ON ALL OTHERS +



HEAD HAIR 8

SINGLE

COMB SCALES

IN SINGLE EVEN ROW = *AEDES LUTEOCEPHALUS* AND *AFRICANUS* (ONLY *LUTEOCEPHALUS* IMPORTANT; LARVAE CANNOT BE SEPARATED)

PECTEN SPINES

IN SINGLE EVEN ROW = *AEDES AEGYPTI*

= *AEDES SIMPSONI LILII*

TUFT OF SIPHON

IN SINGLE EVEN ROW + ABOUT AS LONG AS WIDTH OF SIPHON = *AEDES METALLICUS*

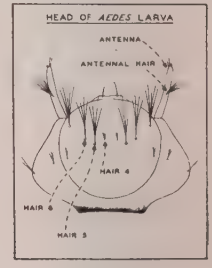
HEAD HAIRS 4,5 AND 6

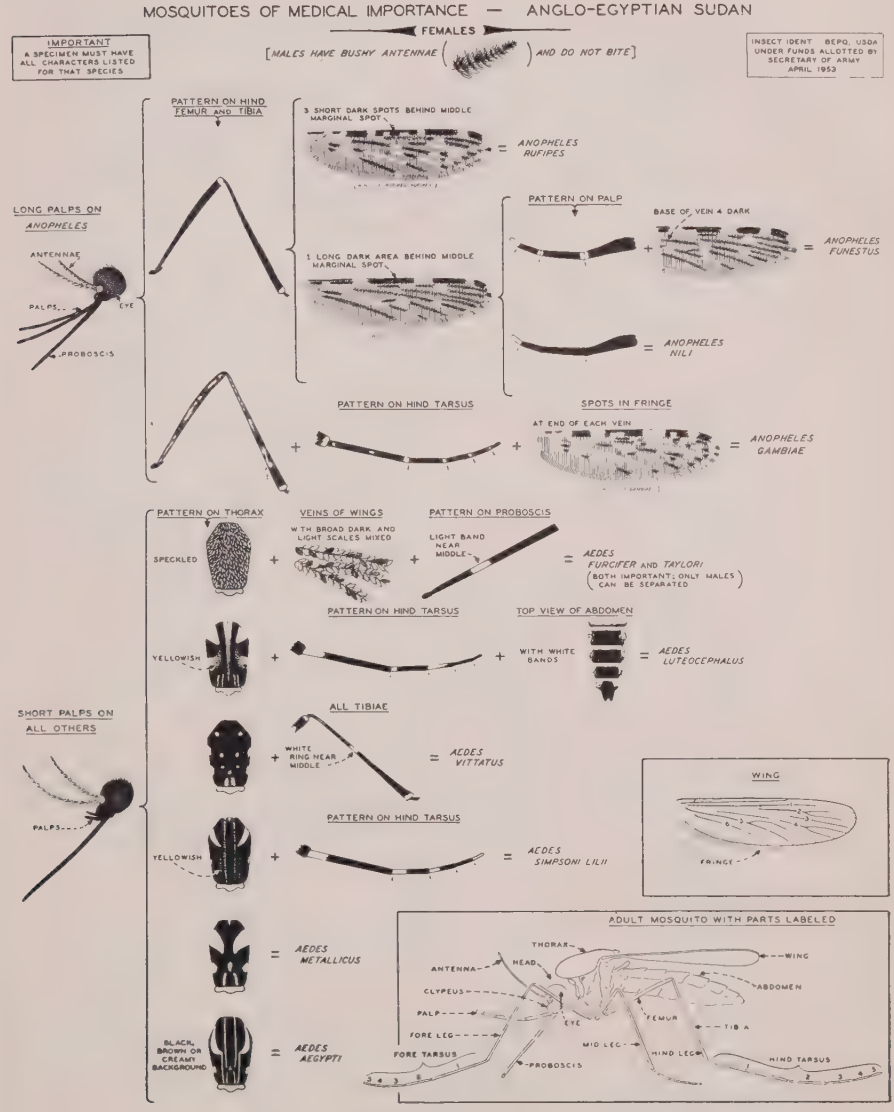
IN IRREGULAR ROW + (NOT) = *AEDES VITTATUS*

ANAL SEGMENT

WITH HAIRED BRANCHES + ABSENT = *AEDES FURCIFER* AND *TAYLORI* (BOTH IMPORTANT; ONLY MALES CAN BE SEPARATED)

HEAD OF *AEDES* LARVA




MOSQUITOES OF MEDICAL IMPORTANCE — ANGLO-EGYPTIAN SUDAN
FEMALES
[MALES HAVE BUSHY ANTENNAE ( ) AND DO NOT BITE]
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES
INSECT IDENT BEPQ, USDA UNDER FUNDS ALLOTTED BY SECRETARY OF ARMY APRIL 1953
PATTERN ON HIND FEMUR AND TIBIA
3 SHORT DARK SPOTS BEHIND MIDDLE MARGINAL SPOT
= ANOPHELES RUFIPES
1 LONG DARK AREA BEHIND MIDDLE MARGINAL SPOT
PATTERN ON PALP
BASE OF VEIN 4 DARK
= ANOPHELES FUNESTUS
= ANOPHELES NILI
LONG PALPS ON ANOPHELES
ANTENNAE
PALPS
EYE
PROBOSCIS
PATTERN ON HIND TARSUS
SPOTS IN FRINGE
AT END OF EACH VEIN
= ANOPHELES GAMBIAE
PATTERN ON THORAX
VEINS OF WINGS
WITH BROAD DARK AND LIGHT SCALES MIXED
PATTERN ON PROBOSCIS
LIGHT BAND NEAR MIDDLE
SPECKLED
= AEDES FURCIFER AND TAYLORI (BOTH IMPORTANT; ONLY MALES CAN BE SEPARATED)
PATTERN ON HIND TARSUS
TOP VIEW OF ABDOMEN
YELLOWISH
WITH WHITE BANDS
= AEDES LUTEOCEPHALUS
SHORT PALPS ON ALL OTHERS
ALL TIBIAE
WHITE RING NEAR MIDDLE
= AEDES VITTATUS
PALPS
PATTERN ON HIND TARSUS
YELLOWISH
= AEDES SIMPSONI LILII
WING
FRINGE
= AEDES METALLICUS
BLACK, BROWN OR CREAMY BACKGROUND
= AEDES AEGYPTI
ADULT MOSQUITO WITH PARTS LABELED
THORAX
HEAD
ANTENNA
CLYPEUS
PALP
EYE
FORE LEG
FORE TARSUS
PROBOSCIS
WING
ABDOMEN
FEMUR
TIBIA
MID LEG
HIND LEG
HIND TARSUS

vector of malaria in the Anglo-Egyptian Sudan, as in all of Africa, is widely distributed in the southern and central Sudan and along the Nile from Uganda to Egypt. It breeds in a wide variety of situations, principally in small pools at least partially exposed to direct sunlight. Because such accumulations of water, as those in foot and hoof prints and irrigation and drainage ditches, are commonly associated with man, and because *gambiae* forms a large proportion of mosquitoes caught indoors and feeding on man, control of this species is the problem of prime importance in malaria eradication. *Anopheles funestus* is considered to be the second most important vector. Its distribution is confined to many parts of the southern and central Sudan and along the White Nile as far north as Jebelein. In contrast to *A. gambiae, A. funestus* breeds in bodies of more or less permanent clear water such as swamps, lakes, edges of rivers and seepage areas, almost always in association with vegetation and shade. The year round character of its breeding and prevalence tends to associate *A. funestus* with endemic rather than with epidemic malaria, the latter being more characteristic of the more seasonal *A. gambiae* populations. The females of *A. funestus* readily enter houses and feed on man. *Anopheles nili* is a subsidiary vector and is subject to marked variation in behavior. Its breeding is typically associated with the marginal vegetation of rivers and streams, and population densities are usually correlated with the seasonal rise and fall of river systems. Adults appear to vary from area to area in their househaunting habits, but naturally infected females have been found in native dwellings, where the species is important if it occurs in large numbers. *Anopheles rufipes* has been found in many localities in the Sudan, especially along the White Nile, and usually breeds in stagnant and semistagnant pools in partial shade. This species is of importance only where it appears in large numbers. In most localities it is rare and is often found resting out of doors.

In addition to these four species of *Anopheles,* the following have been recorded from the Anglo-Egyptian Sudan, or are suspected of being present in that country: *cinereus, coustani coustani, coustani ziemanni, d'thali, implexus, leesoni, macmahoni, maculipalpis, marshalli marshalli, marshalli gibbinsi, multicolor, obscurus, pharoensis, pretoriensis, rivulorum, rupicolus, squamosus squamosus, symesi, theileri septentrionalis, turkhudi* and *wellcomei.*

Yellow fever has not occurred in humans in the Sudan for several years, but sylvan yellow fever is known to be present across the southern third of the country. This disease is typically that of forest-inhabiting monkeys. The monkey-to-monkey transmission cycle is believed to be maintained by *Aedes vitattus* and possibly by *Aedes africanus,* mosquitoes that breed in tree holes and plant containers and inhabit the forest canopy, preferring monkey to human blood. At ground level, however, especially in plantation areas, the principal vector is *Aedes simpsoni lilii,* another plant container breeder. *Aedes simpsoni* feeds on infected monkeys either outside or just within the forest, and having a wide host preference, feeds on man as well, transmitting the virus in a monkey-to-man cycle. *Aedes metallicus, A. luteocephalus, A. furcifer,* and *A. taylori* are believed to act in much the same capacity as *A. simpsoni lilii* to spread yellow fever from monkey to man. *Aedes aegypti* has been included in the key, since it is universally responsible for the presence of urban yellow fever, and is prevalent only at certain times and localities. Dengue has not been reported from this country. In all, approximately 115 non-anopheline mosquitoes are known to be present in the Sudan.

ASSOCIATION NEWS

SCHEDULE OF THE JOINT MEETING
AMERICAN MOSQUITO CONTROL ASSOCIATION
AND
NEW JERSEY MOSQUITO EXTERMINATION ASSOCIATION
MARCH 9–10–11–12, 1954
HADDON HALL HOTEL, ATLANTIC CITY, N. J.

Tuesday, March 9th

9:30	Registration.
10:30–12:00	Opening Paper Reading Session.
2:00–4:30	Paper Reading Session.
5:00–6:00	Get acquainted gathering sponsored by the New Jersey Association.

Wednesday, March 10th

10:00–12:00	Symposium: Insecticides in Mosquito Control.
2:00–2:30	Business Meeting of the New Jersey Association.
2:30–4:00	Paper Reading Session.
4:30	Visit to Local Industry.

Thursday, March 11th

10:00–12:00	Paper Reading Session
2:00–2:30	Business Meeting of the American Mosquito Control Association.
2:30–4:30	Paper Reading Session.
5:00–6:00	Hospitality Hour sponsored by the American Mosquito Control Association.

Friday, March 12th

10:00–12:00	Final Paper Reading Session.

There will be no formal evening sessions. All entertainment facilities of the hotel will be available to the registrants at the meeting. Committee meetings will be announced and times will be assigned.

Invitations have been received by the committee on arrangements for the members of the Association to visit Rutgers University and the various control programs in the Northeast region at the close of the meeting.

PRESIDENT OF THE AMCA, DR. FRED C. BISHOPP

To all AMCA members:

Now is the time to make plans for attending the annual meeting of the American Mosquito Control Association. The 1954 meeting will be held jointly with the New Jersey Mosquito Extermination Association at Atlantic City on March 9–12, 1954. The program committee reports that the meeting is shaping into one of the best yet. Outstanding contributors will include Dr. L. J. Charles from British Guiana; Dr. Z. Saliternik, Director of the Antimalaria Department, Jerusalem; Dr. Horace Gillette, Malariologist, Government of Trinidad; and Dr. F. P. Coyne, Pest Control Section, Weston Point, Runcorn, Cheshire, England. In addition, leading authorities in this country will be present to report on the latest control and scientific information available. A panel on insecticides is being arranged, and this alone should be a "don't miss" item.

George Powers and the New Jersey committees are making big plans on arrangements. He reports that hospitality will be featured, and there appears to be plenty of reason to celebrate. The year 1954 will be the centennial for official government entomology and the contennial of the founding of Atlantic City; also, the Diamond Jubilee of Electric Light will be celebrated along with the 41st annual meeting of the New Jersey Mosquito Extermination Association and the 11th annual meeting of the American Mosquito Control Association.

If you are interested in mosquito control, be sure to come to this meeting. We guarantee it will be educational, beneficial and memorable.

R. E. Dorer, *Program Chairman*

Harry Stage's temporary disappearance from the immediate scene by his acceptance of an appointment for work on mosquito problems in Indo China has brought into sharp focus the many capacities in which he has served the AMCA and *Mosquito News*. As editor of the Bibliography he built up that department into one of the most valuable sections of *Mosquito News*. As chairman of the Good Neighbor Club he was responsible for making many new friends for the AMCA all over the world. When a new advertising manager was needed, he assumed that burden along with his other duties. As a member of numerous committees, as an active participant in all meetings, as a good-will ambassador to the many countries he has visited in the course of his work as an advisor on mosquito problems, Harry has been enthusiastic, untiring, genial, patient.

The AMCA and *Mosquito News* wish him a happy and successful journey. We look forward to letters, news and notes, and scientific papers from him; and we anticipate that wherever he goes a crop of new members and new subscribers will spring up along the way.

In the meantime we are searching for six other people to assume the responsibilities he left behind.

George W. Eager

George W. Eager, one of the pioneers in the mosquito control work of the State of New Jersey, died June 23, 1953, at the age of sixty-eight. He became associated with the Essex County Mosquito Extermination Commission on May 15, 1912, as one of its first employees. At that time, seventy applicants answered an advertisement for inspectors and Mr. Eager was one of the fortunate forty that was selected and assigned to have charge of control activities in a district. During his long service with the Essex County Commission he became successively District Foreman, in 1918; Field Supervisor, in 1922; and Superintendent in charge of the entire program for Essex County, in 1928. In 1943, the additional duties of Secretary were added and he continued in the dual role of Superintendent-Secretary until he suffered a stroke late in 1952. From that time, until the time of his death, George

was on sick leave or on limited duty with the Commission. During his many years of mosquito work he made many friends and had the reputation with associates and co-workers of being a keen, conscientious mosquito control administrator. He is survived by his wife, Katherine Smith Eager. Members of the Essex County Mosquito Commission and the New Jersey Mosquito Control Association regret the untimely loss of a fellow worker.

—George Powers

DUES FOR 1953–1954

Many members of the American Mosquito Control Association have not yet paid their dues for 1953.

Since this Association is a non-profit organization and the advertising matter apppearing in the *Mosquito News* is restricted to a very small field, it must depend largely upon the prompt receipt of membership dues to meet the cost of publishing this journal, and other expenses.

Our membership list is growing rapidly and extends to every quarter of the world with the result that the cost of preparing and mailing bills for dues to each member amounts to a considerable sum and therefore, for 1954, we are going to depend on *this notice to you*, that your dues for 1954 and any dues in arrears are now due and payable.

When Mosquito Abatement Districts or County Commissions forward checks covering dues for a number of members, it would be much appreciated if a list of the members for whom payment is being made, accompany the check. Otherwise considerable time is lost in searching the records before payments can be credited to the proper members.

MAY WE HAVE YOUR COOPERATION.

Sincerely yours,
LESTER W. SMITH,
Treasurer.

Please send remittances to:
Lester W. Smith, Treasurer,
P.O. Box 346,
Metuchen, N. J.

The photograph of Dr. Bishopp on page 260 was received too late for publication in the issue which carried an account of his services to Medical Entomology (*Mosquito News*, Vol. 13, No. 2, June, 1953). It is published herewith for the benefit of his many friends in the Association, and in further ackowledgment of his many services to that organization.

NEWS AND NOTES

Harry H. Stage is en route to French Indo-China, where he will take charge of malaria investigations for the Foreign Operations Administration. He had just returned from attending the Congress in Istanbul, Turkey, and will stop in Manila to attend the Pacific Science Congress and to confer with Dr. A. D. Hess and others in the Philippines. Mr. Stage may be addressed as follows: "U. S. Operations Mission to Cambodia, Laos and Viet Nam, % U. S. Embassy, Saigon, Viet Nam." Letters may be sent via the Department of State, Washington, 25, D. C., but must bear the regular postage, now 8¢ on the first ounce and 4¢ for each additional ounce.

It has been announced recently that Dr. Carroll N. Smith has been chosen as Assistant Leader of the Division of Insects Affecting Man and Animals of the Bureau of Entomology and Plant Quarantine. This selection was made to fill the vacancy created by Mr. Harry Stage's appointment by MSA for work on mosquito problems in Indo China.

Dr. Smith has been actively engaged in research on ticks and insects affecting man and livestock for about twenty years. During the last several years he has conducted investigations on mosquitoes in Alaska, and recently has been Assistant Director of the Orlando, Florida, laboratory of the Bureau.—F. C. Bishopp.

Mrs. Ernestine Thurman is presently under U.S.P.H.S. assignment to the U. S. National Museum where she is working with Dr. Alan Stone on the taxonomy of the mosquitoes collected by her in collaboration with her husband, the late Deed C. Thurman, Jr., during their recent tour of duty in Thailand. She expects to remain in Washington for some months.

Capt. Herbert C. Barnett, MSC, U. S. Army, is nearing the completion of his work at the U. S. Public Health Service Rocky Mountain Laboratory at Hamilton, Montana. Under the general direction of Dr. W. McD. Hammon, of the University of Pittsburgh School of Public Health, Capt. Barnett is studying *Culex tarsalis* and its relation to the encephalitides.

Dr. George J. Burton, who has contributed several papers to *Mosquito News,* writes as follows from Liberia, where he is with a mission of FOA (Foreign Operations Administration): "You may be interested in a few comments about our use of dieldrin. We are now doing house to house residual spraying with 0.3% dieldrin wettable powder and 0.3% dieldrin emulsion, the latter in good houses and the former in huts. Although it was absorbed (or adsorbed?) rapidly into the mud, and showed no apparent crystallization, its effectiveness was demonstrated almost immediately. Our first spraying job was a very large Liberian Army camp, composed mostly of mud huts, in which the mosquito population was very large, and complaints were numerous. Beginning with the same day of the spraying, the mosquitoes diminished to such an extent that bed nets were dispensed with, and we haven't been able to find a single soldier who was bitten by a mosquito after the spraying. The British have found dieldrin to be effective for 9 to 12 months, so apparently one application a year is sufficient. We are working under pressure to complete the job, and have a long way to go before we complete the 4,500–5,000 huts and houses. When I get a chance, I hope to do some lab experiments on mud panels just to see for myself under controlled conditions just how effective the dieldrin is. We have also noted high kills of cockroaches and ants with dieldrin. We don't have very many flies at the present time, so I can't comment on flies. Our sprayers are well-protected with heavy coveralls, respirators, synthetic rubber gloves, and rubber boots. We're using 8002 Tee-Jet nozzles and are getting excellent coverage."

From Harry Stage, Honolulu, Nov. 13: "Saw some good mosquito control business here. . . . Saw the colony of *Megarhinus brevipalpus* and they seem to be thriving. The larvae are reared in individual beer cans and they try to maintain 10,000. In the past 3 months 7,000 adults have been released and the larvae have already been picked up from natural containers. . . ."

From Alaska a PHS mosquito worker, Bill Frohne, reports on a most interesting and profitable three weeks of last summer, spent with the Katmai Project, a Scientific Reappraisal of the Katmai National Monument, Alaskan Peninsula, under the auspices of the National Park Service. The various participants of five Federal agencies collaborating included a geographer, six geologists, three biologists, and three archaeologists. They camped in the wilderness, and found Alaska's hordes of biting flies an infinitely greater impediment to their work than the summer's eruptions in this volcanically active region. Blackflies were exceedingly abundant in the flat tundra zone bordering on the Bering Sea, whereas mosquitoes usually constituted the chief insect problem on the beautiful lakes and mountains of the interior zone. Along the stormy and rockbound Pacific coastal zone (Shelikof Strait) bounding the National Monument on the east it was punkies, snipe flies, or mosquitoes which were the pests at various camps. It is hoped these studies may be continued next summer.—Arctic Health Research Center, Anchorage, Alaska.

From a Letter to H.L.T.: "At present I am working on Eastern Equine Encephalitis at the

Connecticut Agricultural Experiment Station, and have plans to try to colonize some potential vectors. Currently I am keeping a large number of *C. restuans* and may get a colony going for experimental purposes, but am not quite ready to report it yet in print, as I have some trouble with adult mortality due to insecticide-contaminated air and have to kind of keep my fingers crossed with all the colonies."—Robert C. Wallis, Medical Entomologist.

ESTABLISHMENT OF MOSQUITO CONTROL DISTRICT IN GALVESTON COUNTY APPROVED. An election to provide for the establishment and financing of a Mosquito Control District in Galveston County, Texas, was held November 7. The voters approved by a two to one vote the establishment of a Mosquito Control District with authority to levy a tax up to five cents per 100 on property valuation. Dr. Carl A. Nau, President of the Galveston Mosquito Control Association, states that his analysis of the vote which was very light is that all those opposed went to the polls and those who favored the District left it to someone else to vote. He further states that "Inasmuch as the county is now levying the maximum tax in the general fund that is permissible, we have a lot of juggling to get going—but juggle we will."—F. C. Bishopp.

DONALD R. JOHNSON, entomologist, has returned to Washington, D. C., after completing two years in Djakarta, Java, Indonesia. While in Indonesia he was assigned to the Malaria Section of the Indonesian Ministry of Health to assist with the malaria control activities as a part of the U. S. Point IV assistance to that country. At present he is assigned to the Division of International Health of the U. S. Public Health Service in Washington, and will be responsible for certain phases of the overseas malaria control programs, particularly in regard to insecticides, equipment, recruitment, and various entomological problems.

THE ALAMEDA COUNTY (CALIFORNIA) Mosquito Abatement District is one of the oldest and most progressive mosquito control organizations in the United States. The Engineer-Manager, Harold Gray, reports monthly to his Board of Trustees. The following items from the September report are of national and international interest.

The new Manager's Manual for the District, a Manual of administrative procedure on which we have been working for several months, was practically completed in September, except for the index. It covers over 500 typed pages.

A new key to the larvae of mosquitoes in the San Francisco Bay Region, prepared by Assistant Manager Aarons and Miss Bettina Rosay of the Bureau of Vector Control, has been completed and multilithed. The proceedings and Papers of the Twenty-First Annual Meeting of the California Mosquito Control Association, held at Sacramento last February, after a long delay are finally being printed. The Engineer-Manager is Editor.

On request, the Engineer-Manager has prepared and sent a paper to be presented at the Eighth Pacific Science Congress to be held in Manila, P. I. in November. The paper deals with the malaria epidemic at Lake Vera in Nevada County in 1952 and the successful mosquito abatement methods used in 1953 to prevent a recurrence of the outbreak.

We have also had a letter from Espanola in New Mexico, asking for advice on the control of mosquitoes in that area. The Engineer-Manager had discovered the presence of malaria at Espanola in 1920, at the unusually high elevation of about 6,800 feet above sea level, so he was able to offer some suggestions based on experience.

FROM MAURITIUS the Director of Medical Services has written that the Malaria Eradication Scheme has ceased to exist because the eradication of malaria from the island is an established fact. Another result of the application of insecticides over a number of years has been the elimination of *Aedes aegypti*.

THE GREATER WINNIPEG ANTI-MOSQUITO CAMPAIGN operated on an increased budget during 1953, but because of very heavy rainfall the mosquito population became so heavy that efforts to provide relief were not entirely successful. Mr. E. J. Stansfield asked for advice from a number of experts including Messrs. Twinn, Bishopp and Raley. They all agreed that good results can not be expected unless consideration is given to elimination of breeding areas and spraying to kill larvae. About half the Winnepeg funds were spent in larviciding and the rest for fogging. Additional appropriations are being requested to improve and augment the source reduction work.

RESIDENTS OF SANGER, CALIFORNIA enjoyed a season of comfortable evenings, free of annoyance by mosquitoes, according to newspaper reports. The Sanger area consists of about 250 square miles, and is part of the Consolidated Mosquito Abatement District of which Ted Raley is Manager. Clyde Bryson, who is in charge of the work at Sanger, reports that encouraging results have been obtained through an educational program and through preventive measures directed toward source reduction. A large project involved digging a drainage canal through two miles of river bottom to eliminate back water that previously stood all summer. Emphasis has been on larviciding rather than fogging during the 1953 season.

THE UTAH MOSQUITO ABATEMENT ASSOCIATION will hold its annual meeting, March 19–20, 1954 at Magna, Utah. A fine program is being arranged and it is hoped that all interested personnel will be able to attend. More complete information on the meetings can be obtained by writing to Lewis E. Fronk, Sec.-Treas. of the Utah Association at 2441 Grant Ave., Ogden, Utah.

Economic Entomology at Work in the Navy. During the past year, the Bureau of Yards and Docks, in cooperation with the Bureau of Medicine and Surgery, has initiated a program to effect Navy-wide control for insects and rodents of military importance. Large economic losses due to infestation of military supplies, structures, and vegetation, in addition to the manhours lost from disease-bearing and nuisance pests have proved the value of establishing economic entomologists on the technical staff of the Bureau of Yards and Docks and in the Naval Districts. These technical consultants work with the supply personnel in the protection of subsistence and other stored products, with the Medical Personnel in organizing effective disease vector control and with trained control personnel to control household and vegetative pests. At the present time the positions of economic entomologists as Director, Pest Control Division, are established on the technical staffs of the District Public Works Officer at the following locations: Fifth Naval District, Norfolk, Virginia; Sixth Naval District, Charleston, South Carolina; Eighth Naval District, New Orleans, Louisiana; Tenth Naval District San Juan, Puerto Rico; Eleventh Naval District, San Diego, California; Fourteenth Naval District, Honolulu, T. H.; Fifteenth Naval District, Canal Zone, Panama.

—George L. Hutton

Don Micks writes that he has left Galveston for an academic year at the Universita di Pavia, where he has been invited to continue his biochemical studies of the *Anopheles maculipennis* complex as a complement to the work of Dr. Frizzi on the salivary gland chromosome patterns. Micks will work at the Instituto di Zoologia and also plans to spend time with Mario Pavon. His expenses will be underwritten by Fulbright funds.

The California Mosquito Control Association has approved the following motion: "That the California Mosquito Control Association, Inc. underwrite the expenses of sending one (1) or more delegates to each annual meeting of the AMCA and it is hereby recommended that the delegate be the CMCA president, whenever feasible. The total sum to be allocated for this purpose (is) not to exceed $500.00 annually, but in no case shall the CMCA share more than one-half (½) of the normal expenses involved in sending one or more delegates."

VIRGINIA MOSQUITO CONTROL ASSN.

300 Essex Building, 315 Plume Street, Norfolk, Virginia

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EDITORIAL SECTION

THE PLACE OF SWANS

Just 100 years ago, in 1854, a portion of a swampy, mosquito-infested sandbar known as the Place of Swans ("Absecon" to the Indians), was incorporated under the name Atlantic City, New Jersey.

In May of the same year that Atlantic City was incorporated, 1854, the first "official" entomologist in the United States, Dr. Asa Fitch, became State Entomologist of New York, and, a month later, Townsend Glover became officially associated with the U. S. Government as an entomologist.

These two centenaries, one of a great city, and the other of an important applied science, have more than a casual connection, for it is safe to say that the Place of Swans could never have become the Place of Play as we know it today, a world capital of relaxation and recreation, had it not been for the official acknowledgment, coming the same year of its incorporation, that the control of certain insects was a public responsibility.

And it is significant that in the exact midpoint of that century, 50 years after the founding of the city and of the science, and 50 years ago (in 1904), there appeared Dr. J. B. Smith's monumental report on the mosquitoes of New Jersey, which was in preparation during the long gestation period of publicly supported mosquito control and appeared just in time to be used as a manual of guidance for those who officiated at its birth.

Other developments followed at intervals so well-timed that we can appropriately celebrate several additional anniversaries in 1954, all involving mosquitoes, and all occurring in New Jersey in or near Atlantic City.

In 1914, that is, 40 years ago, the New Jersey Mosquito Extermination Association held its first annual convention. In 1944, 10 years ago, the Eastern Association of Mosquito Control Workers, which had been sired by the New Jersey Association, enlarged its scope still further and became the American Mosquito Control Association, which became incorporated under New Jersey laws.

Now, on the 100th anniversary of Atlantic City, the 100th anniversary of Official Entomology, the 50th anniversary of official Mosquito Control, the 40th anniversary of the New Jersey Mosquito Extermination Association, and the 10th anniversary of the American Mosquito Control Association, on March 9–12 the two Associations will again convene in Atlantic City. No time could be more appropriate, nor any place more fitting, for these two associations to meet together to hear the swan song of the mosquitoes in the City of the Swans.—D. L. C.

"I come here each year, not for the purpose of talking to you but for the purpose of picking up points. I think nowhere in the world is there as much practical knowledge on the subject of mosquito extermination as exists in the State of New Jersey."—L. O. Howard, speaking at a meeting of the N. J. Mosquito Extermination Association in 1916.

BIBLIOGRAPHY

REFERENCES TO LITERATURE OF INTEREST TO MOSQUITO CONTROL WORKERS AND MALARIOLOGISTS

HELEN SOLLERS

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AERIAL APPLICATION

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